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Video Tape Recorder Design

These papers constitute the first technical discussions of the Ampex video tape recording system, presented on October 11, 1956, at the Society's Convention at Los Angeles. Various problems encountered in the development of the recorder are discussed and the steps taken toward solutions are described in detail. These papers were first received on October 23, 1956, and in final form on March 11, 1957, from the authors at Ampex Corp., 934 Charter St., Redwood City, Calif.

Comprehensive Description of the Ampex Video Tape Recorder

By CHARLES P. GINSBURG

The subjects covered in this paper include: the choice of a system approach, the configuration of elements on the top plate, the magnetic pattern on the tape, the video electronics, the control system, principal factors in the response of the overall system, head life and tape life, and a note on splicing and editing.

The Ampex Video Tape Recorder, including the head assembly, being inspected last year by Charles P. Ginsburg, senior project engineer in charge of video development, and Phillip L. Gundy, manager of the audio division of Ampex Corp.

The Choice of a System Approach

In making any comparison among various approaches for recording video on magnetic tape, a fundamental premise can be made which defines the state of the art. This premise concerns the shortest useful recorded wavelength. The recorded wavelength is, of course, equal to the head-to-tape velocity divided by the frequency of the signal. For an audio recorder operating at 15 in./sec, a 15-kc signal has a wavelength of 1 mil, that is, 1/1000 of an inch.

Although in professional audio recording it is possible to obtain excellent results with wavelengths as short as $\frac{1}{2}$ mil, for other applications the shortest useful wavelength might be either greater or less than $\frac{1}{2}$ mil, depending on the application involved. For example, it might be possible to cite some application where only a 20-db signal-to-noise ratio is required, in which case it might be reasonable to reduce the size of the magnetic playback gap to a dimension smaller than the customary $\frac{1}{4}$-mil dimension in order to get an increase in the null frequency, and then to use recorded wavelengths considerably shorter than $\frac{1}{2}$ mil.

On the other hand, some very practical applications of tape recorders have performance requirements so stringent that it is necessary to operate with recorded wavelengths considerably greater than $\frac{1}{2}$ mil. Although some investigators have obtained significant results working with wavelengths as short as $\frac{1}{16}$ mil and even less, we believe that such considerations as life of the equipment, reliability, and ease of manufacture should restrict

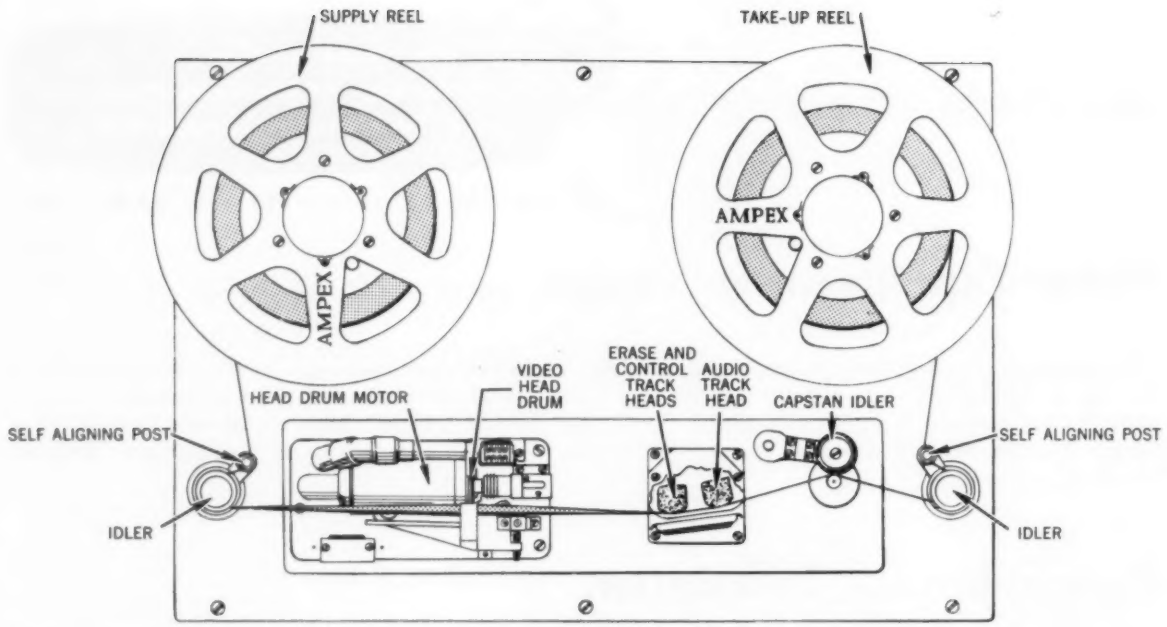

Fig. 1. Top-plate layout.

wavelengths for the video tape recording application to a dimension not less than $\frac{1}{5}$ or $\frac{3}{10}$ mil.

For several years it has been known to those intimately connected with or interested in the extension of the field of magnetic recording into much wider band applications that there are three promising approaches toward the development of a tape recorder for television use. The first and most obvious approach is a brute force method in which the tape is pulled past the magnetic head at a speed sufficiently high so that the recorded wavelength is not greater than, let us say, $\frac{1}{5}$ mil. Thus, to record a 4-mc signal a tape speed of 800 in./sec would be required if one were working with a top information packing density of 5 kc/inch of tape speed. Even with an increase of this packing density to 15 kc/inch, which approaches the greatest packing rate which has been obtained even under laboratory conditions, the required tape speed would still be in excess of 20 ft/sec. The accompanying problems in such a system, which range from the awkwardness of physically handling the reel of tape to the extreme difficulty in obtaining adequate head life, and even of producing the heads in other than laboratory fashion, would indicate that the approach might not be the best for the television application.

The second system is one which uses several channels in a time multiplexing fashion. The essence of such an approach is to sample the information to be recorded by each of the several channels consecutively and thus to reduce the bandpass requirements of each channel by a factor roughly equal to the number of channels employed. The obstacles encountered with this approach lie in the difficulty of maintaining during playback channel-to-channel phase relationships the same as they were during the recording process. This problem is almost exclusively mechanical and is, in the greatest part, due to the very severe effect on phase relations caused by a minute amount of tape skewing.

Again, this problem is intensified as the effort is made to use shorter and shorter wavelengths for the purpose of obtaining reasonable tape speeds. In following a development plan based on this type of approach, investigators have found it necessary to employ rather unique and elaborate correction devices, one example of which is a servo mechanism which varies the inclination of a stack of multiplexing heads, in order to compensate for tape skew. Within the requirements of a system for recording television programs, this approach is workable provided the wavelengths are sufficiently long so that the remaining error with a servo compensation system is tolerable in terms of the reproduced picture. In practice, it turns out that the restriction on permissible shortness of the wavelengths may still run in the order of that corresponding to a packing density of 2 kc/in. of tape speed. This means that in a ten-channel time division multiplexing system with a 4-mc bandpass, a tape speed of 200 in./sec would be required. A considerable amount of work has been done by some investigators along lines that are essentially combinations of the first two methods mentioned, with problems following the trends of both.

The third approach is one which has been pursued in developing the Ampex system. A very high writing speed is obtained by recording transversely across the tape while pulling the tape at a rate dictated by the width of the recorded tracks and the number of these tracks laid down per second. In the Ampex machine four heads are mounted in a drum so that their tips protrude very slightly past the periphery of the drum. The heads are precisely aligned in a rotational direction, so that each head gap is separated from the gap of the adjacent head by 90°. The drum diameter is approximately 2 in. and the rate of rotation is 240 rps, which gives a writing speed of about 1500 in./sec. The tape is 2-in. wide, which means that during the complete sweep of a head transversely across the tape, about 120° of arc are described. The soundtrack is laid down at one edge of the tape by means of a conventional stationary magnetic head, and a control system signal is recorded similarly at the other edge of the tape. The same rotating video heads are used for record and playback.

Configuration of Elements on the Top Plate

Figure 1 shows the top-plate layout. The tape is fed from the supply reel, around the supply idler, past the rotating drum and an assembly of stationary erase, record, and reproduce heads of conventional design, between the capstan and the capstan idler, around the take-up idler and to the supply reel. The stationary erase head for the audio track is located past the rotating drum; it erases the top edge of the tape after the video sweeps have been written on the tape by

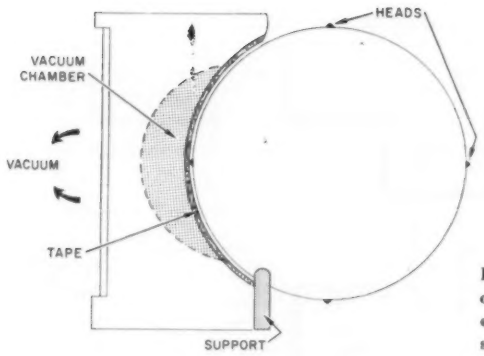

Fig. 2. Cross-sectional view of recording drum, with concave guide and tape shown in operational position.

the rotating video heads. It is unnecessary to erase the lower edge of the tape prior to recording the control signal. For the audio channel as well as for the control channel a combination record/-reproduce head is used. These heads are located as shown in Fig. 1.

Figure 2 shows in cross-section the drum, the tape and the concave guide or shoe which is used to cup the tape around the drum. Vacuum is "pulled" or exhausted from the shoe side of the tape as part of the tape stabilizing means.

The Magnetic Pattern on the Tape

Figure 3 shows the magnetic pattern on the tape at various points. The top sketch shows the magnetic pattern written completely across the tape by the rotating video head. The tracks are only 10 mils wide. The 2-in. tape travels at 15 in./sec, which allows about 5 mils of spacing between adjacent edges of the tracks laid down by the rotating head. The middle sketch shows the magnetic pattern on the tape after passing the audio and control track record/reproduce assembly. During playback, the interference in the control channel due to the incidence of the transverse video tracks does not exceed the required signal-to-noise ratio in the control channel. The tape dimension measured from the edge of the magnetic pattern toward the top of the tape after erasing of audio has occurred, to the top edge of the recorded control channel signal, exceeds by about two television picture lines a length which corresponds to 90° of arc. This means that successive recorded video tracks have an information overlap amounting to about 130 μsec. The purpose of this overlap is to allow during playback a fairly broad interval at any time during which electronic switching can take place. This process will be discussed in detail in the succeeding paper, "Commutation and Switching."

The Video Electronics

Figure 4 is a somewhat simplified block diagram of the complete system. The diagram breaks down into two major parts: the video electronics (certain aspects of which will be covered in much greater detail in companion papers) and the control system. The video signal is fed into the machine at standard level, is amplified, and goes to the modulator. The output of the modulator is fed through a drive amplifier to four separate record output amplifiers and is coupled to the rotating heads through slip rings and brushes. Inasmuch as an extensive discussion of the nature of the modulation system will be presented in the third paper of this group, at this point it might be merely stated that the modulation system records a frequency modulated wave in which the observable effects of amplitude variations of the modulated wave are, within certain limits, undetectable. Within these limits, the only result of failing to achieve during playback 100% registration of the heads on the previously recorded tracks will be a slight increase in the noise level.

In the playback mode the switches associated with the rotating heads are thrown to the preamp position, and thus the head output signals are passed through the respective preamps, and constitute the four input signals to the electronic switcher. The function of the switcher is to pass the output of each preamp only when it should be passed. This is for the purpose of eliminating the additional noise which would exist by transmitting an undesired signal or what is essentially the same thing, a signal at the wrong time. In short, the output of the switcher consists of the consecutive transmission of the signal read off by the individual heads. The signal appearing at the output of the switcher is still the frequency modulated wave. This rf signal is then passed to the demodulating unit which amplifies and clips, and then demodulates the signal. Following detection, the video signal is passed through video amplifiers and appears at the output of the machine in the same form in which it was originally presented at the input.

The Control System

It might appear a most formidable problem to control the heads so that they are in the right place at the right time. Actually, the control system is fairly

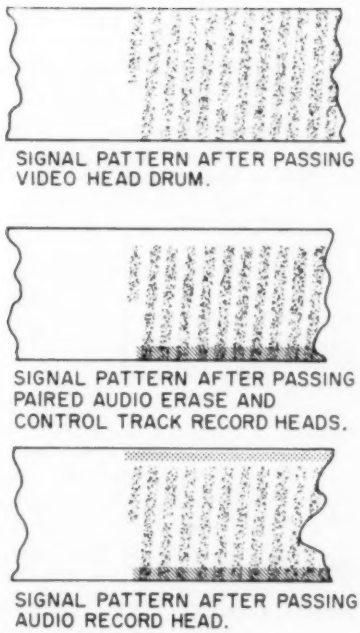
SIGNAL PATTERN AFTER PASSING VIDEO HEAD DRUM.
SIGNAL PATTERN AFTER PASSING PAIRED AUDIO ERASE AND CONTROL TRACK RECORD HEADS.
SIGNAL PATTERN AFTER PASSING AUDIO RECORD HEAD.

Fig. 3. Magnetic pattern in sequential steps through head assembly.

simple. Sixty-cycle power line frequency is multiplied to 240 c (cycles per second), which is then applied to a power amplifier which drives the drum motor. A light source is focused on a disk mounted on the drum motor shaft. The disk reflects the light to a photoelectric cell. The surface of this disk has 180° of reflecting surface and 180° of nonreflecting surface. Thus, a square wave is generated at the output of the photocell which has a 1:1 correspondence with the rotation of the drum.

This 240-c square wave is passed through a 240-c bandpass filter and is then fed to the control track record electronics and thus written on the lower edge of the tape by the control track head. At the same time the 240-c square wave is divided down to 60-c, the 60-c signal being used to drive the capstan motor power amplifier during the record process. During playback, the drum runs in the same fashion as in record, but the capstan motor is driven under servo control (Fig. 5). The 240 c previously recorded on the tape is read back by the control track head, amplified by the control track playback electronics and constitutes one input to the servo amplifier.

The other input, which is the reference input to the servo amplifier, is the 240-c sine wave derived from the photocell impulses. These two 240-c signals are compared in phase, an error voltage is generated which is a function of the phase difference between the two signals, and this error voltage is applied to a low-pass filter whose output is fed to the grid of a reactance tube. The reactance tube is

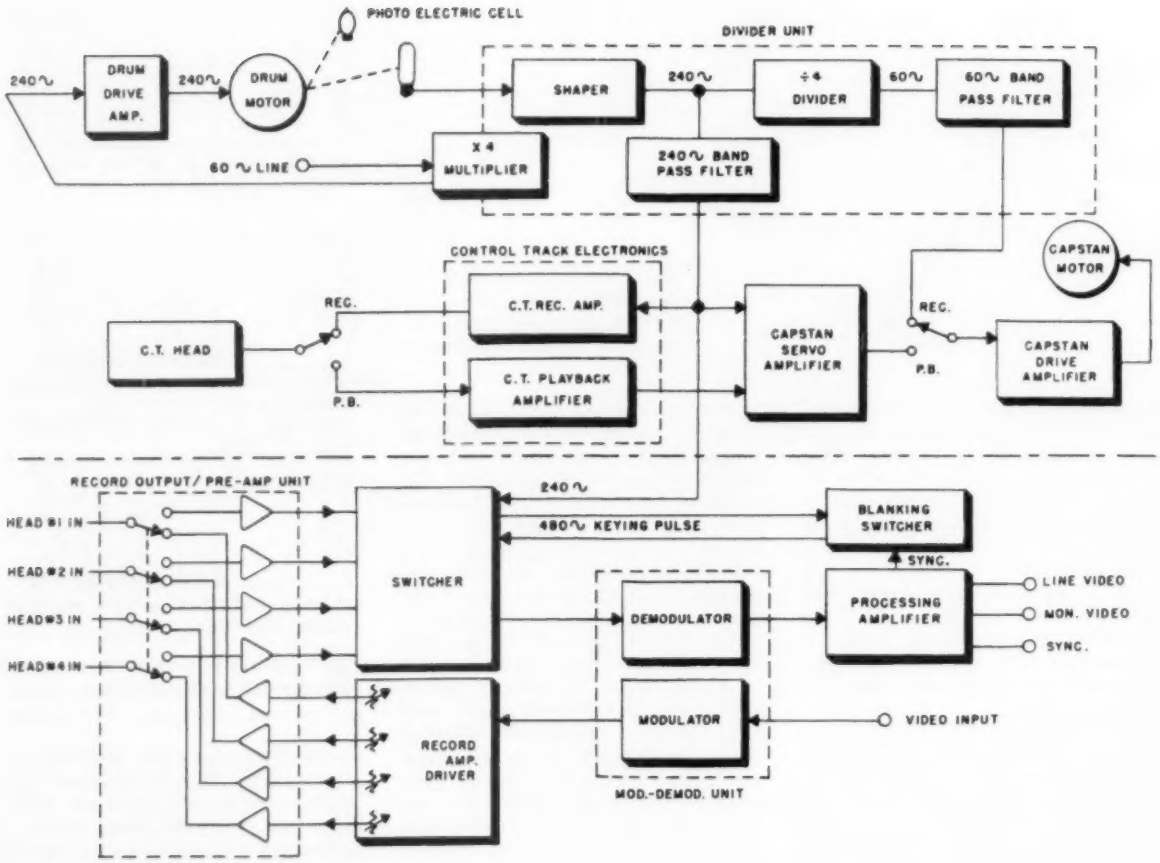

Fig. 4. Simplified block diagram of complete system.

one of the frequency determining elements of a Wien bridge oscillator. Thus, the Wien bridge oscillator frequency, which is nominally 60 c, is controlled by the phase variation between the two 240-c signals. Since it is the output of this oscillator which is applied to the input terminals of the capstan drive amplifier during playback, this method of control insures proper registration during playback of a given head upon the track which it previously recorded. The capstan motor is speeded up when the recorded 240-c signal (and therefore the tape) is lagging behind the photocell 240-c signal, and correspondingly slowed down when it is leading.

Any minor adjustments in tracking which might be desirable because of such factors as time-varying phase changes caused by temperature effects on circuit components, and temperature and humidity effects on the tape length between cylinder and control head, can be made by adjusting a vernier phasing control located on the operating panel of the machine.

Principal Factors in the Response of the System

A detailed and precise analysis of the response of the entire system is extremely complex. Although a direct recording approach, as opposed to a carrier system such as we are using, would have great pitfalls, especially in trying to obtain a very slow tape speed, the direct recording method would be far easier to analyze. We trust that the technical and economic advantages of the particular modulation system used in the Ampex video tape recorder outweigh the burden of having to interpolate, invert, translate and extrapolate certain nonlinear functions in particular elements of the system in an attempt to understand just how to increase horizontal resolution by 40 lines, or to reduce the rise time or overshoot by 20%. Here will merely be described very briefly some of the factors involved in the frequency response or transient response of the system.

The output circuits being used in recording consist of so-called constant current amplifiers. The type of amplifier that is used is a plate-coupled pentode in which the impedance in series between the plate and the B supply is sufficiently large in comparison with the impedance of the head circuit so that the amount of signal current going through the heads is essentially independent of frequency. An important consideration which precludes the possibility of keeping the current through the heads at an absolutely constant amplitude and with linear phase shift is the resonance of the head circuit itself. The inductance of the head windings, in conjunction with the various shunt capacities which couple a particular head winding to various other impedances as well as to ground, gives us a fairly complex network, the principal complexity arising from the existence of antiresonant circuits. An obvious solution to the problem of having the antiresonant frequency within the range of the required bandpass spectrum is to put fewer and fewer turns on the heads. However, there is a real limitation in this direction since a smaller number of turns gives less playback voltage. In a practical solution to this problem we have found it desirable to locate the antiresonant frequency within the range of at least some of the modulation components which are being passed.

Figure 6 gives an indication of the various impedances in the head circuit. Because of the f-m character of the system, it is advantageous to saturate the tape during the recording process. It might be desirable to saturate the tape for all frequencies involved. Since resonance prevents us from having a truly constant output amplifier, one might reach the con-

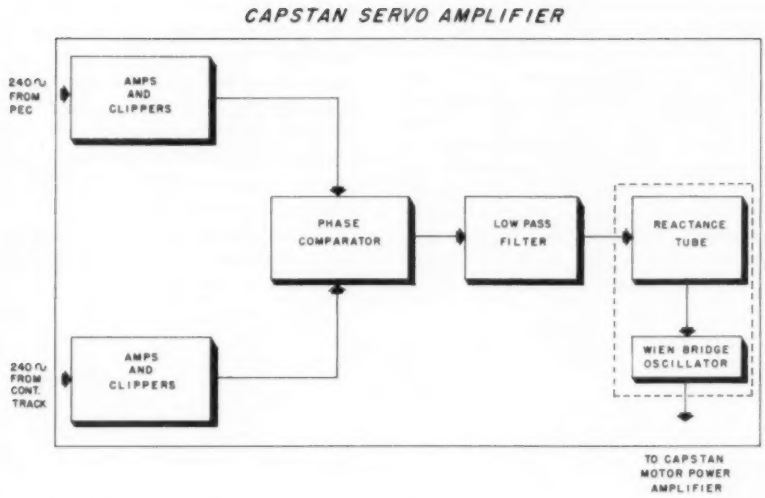

Fig. 5. Block diagram of capstan servo control.

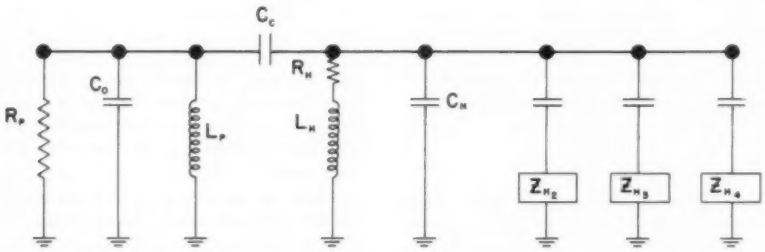

Fig. 6. Equivalent circuit for video head circuit during record.

clusion that the voltage level being delivered to the grid of the output stage could be of sufficiently high value so that the tape would be saturated even by the lowest amplitude current. It turns out that to do this is not as simple as it sounds.

Figure 7 shows a family of curves plotting output playback voltage amplitude (e_0) vs. record current for various wavelengths. At a 2-mil wavelength the output voltage will remain essentially at the maximum, even if a record current considerably in excess of the saturating level is used. At a $\frac{1}{2}$-mil wavelength, however, a very definite current optimum appears, in terms of playback voltage amplitude. In the case of the $\frac{1}{4}$-mil wavelength the curve is even sharper. Thus, unless one considers using very accurate amplitude or phase equalization, or both, the selection of the best possible input voltage to the record amplifier must be determined either by extensive analysis, if the understanding of the overall characteristics of the system justifies this, or by inspection of the reproduced picture.

The phenomenon exhibited in Fig. 7, rather well known to those in the magnetic tape recording industry, is due to self-demagnetization during the record process. The actual wavelength at which the peaking effect occurs in the playback voltage as a function of record current can be changed, within certain limits, by variations in the head design.

Another complicating element in the system is made up of the combination of a 6-db rise per octave of frequency together with a frequency varying attenuation of this characteristic due to core losses in the magnetic head. In view of the many variables, some dependent and some independent, of the type already mentioned, it might be rather interesting to note the results obtained some time ago when measurements were made on a laboratory machine from the input to the record amplifier through the output of the playback preamplifier. The machine had been set up for optimum picture under one given set of conditions. The amplitude vs. frequency curve was flat with no bumps or holes in the region from 750 kc to 6 mc with a gradual taper of about 2 db at 6 mc. However, it should not be concluded that this flat amplitude characteristic gives the desired performance under all conditions.

Head Life and Tape Life

When the engineering model was demonstrated at the NARTB Convention in Chicago in April 1956, we stated that the life of a set of heads was expected to be about 100 hours and that the tape life should be about 100 passes. At the present time we believe that the figures are conservative but do not wish to alter them until laboratory tests as well as field tests have been conducted on the prototype units. As the heads wear in, no degradation occurs in pictures reproduced from the machine. On the contrary, it is likely that some slight improvement in picture quality will be detected during the life of the head. This is due largely to the fact that the amount of shunting in the gap decreases as the head tips are worn down. As the shunting in the gap decreases, the heads become more efficient. It is difficult to say at this time whether or not such improvements will be detectable except by instrumentation.

The beginning of the end for a given head comes when the gap depth is reduced to zero, that is, to a chisel point. As the head continues to wear past this point the gap increases in width and the null frequency, due to gap effect, falls off correspondingly. However, the rate of wear is sufficiently slow so that when this point is reached the head will still be capable of making satisfactory recordings for some hours. The first signs in the reproduced picture of the end of the useful life of a head will be the appearance of a certain characteristic type of noise peculiar to this particular cause. This noise is for some time sufficiently small in its subjective effect on the picture so that for at least several recording and reproduction processes after the milestone has been reached the picture will still be commercially acceptable.

From the tests which have already been conducted it appears that, up to a certain point in the life of the tape, the reproduced picture will show little or no deterioration due to tape wear, and, in fact, in some cases may show an improvement in picture quality with reference to that type of noise denoted as snow. At this point, some deterioration in the picture will appear as an increase in dropouts, which would appear on the picture monitor as occasional short transients. Another type of deterioration which earlier appeared during the course of development of the system was a clogging of the head gap by the oxide or binder after a certain number of plays.

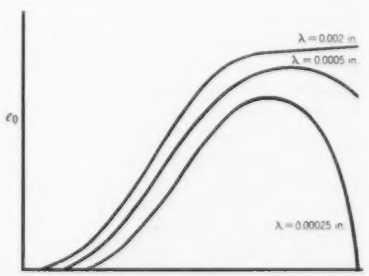

Fig. 7. Family of curves illustrating self-demagnetization effect.

This difficulty has been completely eliminated due primarily to the efforts of the tape people to improve their product for the rotary head video tape application. Unless a tape has been run for several times its recommended life, degradations in the reproduced picture due to tape wear do not affect the gray scale or the resolution.

A Note on Splicing and Editing

The machines now being delivered are to be used for the delay of network programs. They do not have special facilities for performing splicing and editing functions. On the first machine a tape can be cut with a pair of scissors and spliced with splicing tape. If a recording is made over such a splice there will be very little disturbance in the reproduced picture. If such a splice is made after recording, and the tape is then played back, a few seconds will be required for the control system to restabilize itself. We are fully aware of what the television industry wants in terms of splicing, editing and switching facilities in the regular production machines which will be delivered next year. Those machines differ primarily from the prototype run to be delivered this year in the fact that they are interchangeable, that is, any machine will be able to play back a tape made on any other machine. In addition, next year's models will incorporate facilities for splicing, editing and switching which we believe will be completely satisfactory to the industry.

The Modulation System of the Ampex Video Tape Recorder

By CHARLES E. ANDERSON

The modulation system will be considered first as to why such a system is necessary; then as to possible types of modulation; and finally a complete examination of the specific solution is presented.

Why a Modulation System Is Necessary

In an ordinary tape recorder operating in the audio range all of the problems encountered in higher frequency systems are to be found. Let us first examine the low-frequency end of the spectrum. At frequencies much lower than 50-c (cycles per second) the flux recorded on the tape changes very slowly per unit of tape length and the resultant voltage output is very low. If the speed of the tape were increased from a usual 7½ in./sec to 150 in./sec, or an increase by 20, there would be difficulty in reproducing not 50 c but 1000 c. Since an ordinary television signal has frequency components as low as 30 cycles, the resultant reproduction from tape would be poor. The problem is well known and most of the high tape speed, direct recording systems have various ways to overcome the shortcomings.

The high-frequency end of the spectrum is a different situation completely. Here the problem is one of keeping a wavelength on tape greater than the gap of the playback head. This can be done in two ways: either by increasing the tape speed so a wavelength is stretched over a longer section of tape, or by decreasing the gap. Usually both are done. The ultimate in present techniques seems to be a gap stated as capable of producing 20 kc/in. of tape speed, which represents an 0.05-mil effective gap.

From these facts it can be seen that the two requirements are incompatible; but what is to be done? The question we asked ourselves over and over was if we could somehow process the video signal and fit it into the space available. The problem was further complicated by having the signal chopped at approximately a 1000-c rate by the rotating heads used in the Ampex process.

In studying the possibilities we came across unusual and interesting methods other groups had used at various times and in various fields to transmit the video signal. Of the more applicable methods the idea of modulating a carrier seemed most practical. This would solve the problem of low-frequency response but the high end problem would remain. An old rule of thumb that seems to be pretty true is that for reasonably low distortion with simple equipment, the carrier should be at least ten times the highest modulating frequency. This would have meant a carrier of 4 mc × 10, or 40 mc.

Further reflection, however, showed that the nature of a television signal makes it possible to tolerate high orders of a certain type of distortion (caused by the use of too low a carrier frequency) without degrading the picture as observed by the human eye.

[*Editor's Note:* The oral presentation at the Convention benefitted from the projection of two slides which it is not feasible to publish, due to the reduction in size necessary for the *Journal* page and due to the inevitable overall degradation in the processes of photoengraving and printing. The slides showed images respectively integrating and not integrating noise and distortions in successive frames. The image with integration was much more acceptable. It is recognized, of course, that photographic evidence of this kind must be used with great caution.]

It could be seen that the resolution wedge blurred at a frequency approximately 0.8 that of the carrier, demonstrating that very little of the available spectrum space would be lost by employing a modulation system with the low carrier frequency as described, while gaining much in simplifying the low-frequency problem.

Amplitude modulation was tried quite early in the experiments, but it had several disadvantages as far as using it with a rotating head system. Since four heads spaced 90° apart on a drum are used, any variation in head sensitivity or output would give stripes across the picture each of different video level or contrast. This could probably be compensated for by gain controls on a short term basis if it were not for another problem.

Each track is 10 mils wide with 5 mils between tracks. A head on playback is supposed to follow a recorded track exactly, but variations in tape velocity in the direction of tape travel (the 15-in./-sec direction) will cause the head at least partially to leave the track thus causing a loss in carrier output. This resulted at the time in an undulating envelope on the carrier of perhaps 4 to 5 db peak-to-peak. Present machines, of course, are much superior in this respect to earlier laboratory models.

What all this means is that an instantaneous AGC system is needed. The problems in such a circuit are many, and the idea of IAGC was dropped after some preliminary thought was given it.

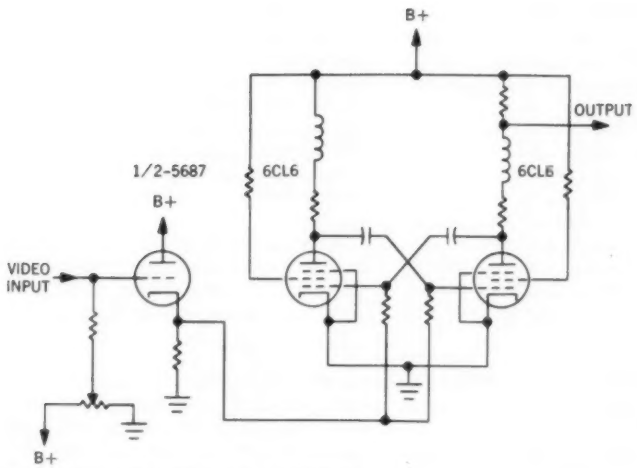

Fig. 1. Simplified schematic of modulator.

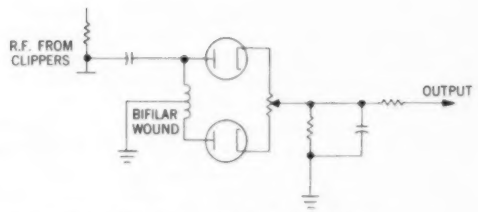

Fig. 2. Simplified schematic of demodulator.

It was recalled at this point that the Federal Communications Commission had conducted some experiments in 1949 to determine the feasibility of transmitting a television image by frequency modulation over existing channels. At that time the FCC was plagued with the co-channel and adjacent channel interference problems, and it was felt that FM might offer a solution. The results were excellent except for the problem of multipath phase distortion. The FCC sent us what data they had, and we resolved to try frequency modulation although several unknowns existed. We could find no mathematical derivation for what happened when the modulation frequency (f_m) approached the carrier frequency F. All the classical derivations* make the assumption that f_m does not approach F. Also, we wanted to violate the condition that $\Delta F << F$, where ΔF represents the derivation from the center frequency F.

Another question was what would happen when FM was transmitted with only one set of side bands.

By keeping β (where $\beta = \Delta F/f_m$) small, only one pair of side bands is generated. If β is 0.1 (meaning that the ratio of modulating frequency to deviation is 10:1), the second pair is only 0.1% of the unmodulated amplitude of the carrier. If β is 0.5, the second pair is still only 3% of the amplitude of the carrier while the first pair has increased to 24% of the unmodulated carrier amplitude. The first pair of sidebands occurs at frequencies $F \pm f_m$, the second pair at $F \pm 2 f_m$.

Further exploration by our associate Harold Walsh, was rewarded by the discovery of a paper published in 1948.† He gave an exact solution to the dominant equation for the case $\Delta F/F < \frac{1}{2}$. Mr. Cambi's resultant exact solution was still cumbersome for dealing with everyday problems; however he made several simplifications that gave an equation sufficiently accurate for most work and at the same time simple. Table I shows the results obtained from Mr. Cambi's equations as well as the more conventional Bessel function distribution. The conditions are:

$$\Delta F = 0.1\ F_c$$
$$f_m = 0.1\ F_c$$
$$\beta = 0.67$$

Column I is the exact solution. Column II is from the approximation and Column III is the usual Bessel function method. Of particular interest is the lopsided distribution and the fact that the example does not include folded lower sideband components.

Table II is the tabulation of sideband components calculated from Mr. Cambi's approximate equations, for a different set of parameters. The parameters were chosen to represent typical values in use in the Ampex system.

$F = 5$ mc $\quad \Delta F = 1$ mc

Table I. Analysis of Sideband Energy Distribution Showing Proximity of Values Calculated by Various Methods.

Spectrum component n	Exact solution (Cambi) I	Approximate solution (Cambi) II	Conventional solution (symmetrical) III
−5			.00003
−4	.00002	.00002	.00056
−3	.00130	.00108	.00673
−2	.02883	.02501	.06001
−1	.28619	.26036	.35333
0	Unity	Unity	Unity
1	.43754	.41007	.35333
2	.11057	.10043	.06001
3	.02157	.01915	.00673
4	.00360	.00314	.00056
5	.00054	.00046	.00003
6	.00007	.00006	
7	.00001		

The general drift of the sideband distribution is more exaggerated than in Table I. While the FM in Mr. Cambi's computation assumes sinusoidal transitions, and in the Ampex system is obtained with a multivibrator, this general drift is still illustrative.

In a single sideband transmission of AM we need only transmit enough of the extra sidebands to insure that the filter does not introduce too much phase shift at the carrier frequency. In FM however, one has to think of both sidebands, carrier and instantaneous frequency. The instantaneous frequency is what does the work, and it is created by the sidebands. At least, therefore, either all upper or all lower sidebands must be transmitted, but since ΔF does the work, we must also transmit both its upper and lower excursions. This means that in our case if F = 5 mc, f_m = 4.5 mc, and ΔF = 500 kc, then the system should have a passband extending at least from 5 − 4.5 or 500 kc to 5 + ΔF or 5.5 mc.

Table II. Sideband Energy Analysis Using Simplified Calculation.

Spectrum component	Modulating Frequencies, f_m			
	1 mc/s	2 mc/s	3 mc/s	4 mc/s
A_5	.007			
A_4	.025	.007	.004	.002
A_3	.087	.030	.016	.015
A_2	.264	.118	.068	.068
A_1	.654	.408	.328	.289
A_0	Unity	Unity	Unity	Unity
A_{-1}	.356	.112	.030	.008
A_{-2}	.039	.002	.008	
A_{-3}	.002			

The Factor of Signal-to-Noise

One major item of interest remains that has not been discussed as yet, and that is the question of signal-to-noise. If an AM carrier were used, the signal-to-noise of the detected signal would be roughly the same as that of the carrier and the same as that of a direct recording. With FM, as everyone knows, the situation is quite different, and unfortunately the different situation is not a favorable one. In ordinary FM broadcasting β is quite large and the bulk of the transmitted energy is in sidebands, and the ability to reject noise is superior to AM. As β is decreased, the advantage de-

* August Hund, *Frequency Modulation* (New York, McGraw-Hill Book Co., 1942), pp. 347–351.

† Enzo Cambi, "Trigonometric components of a frequency-modulated wave," *Proc. IRE, 36:* pp. 42 et seq., Jan. 1948.

creases and finally disappears when the FM sideband energy is less than that in 100% amplitude modulation. Since $\beta = \Delta F/f_m$, in audio FM broadcasting the smallest β possible is 75 kc divided by 15 kc, or 5. In the Ampex video system the deviation is 1 mc and f_m is 4 mc, giving a β of 0.25 and resulting in a wide band signal-to-noise figure inferior to AM. As was previously pointed out, however, FM does solve the low-frequency variations in carrier output that rule out AM, so FM is the more rewarding solution, and adequate effective signal-to-noise ratio can be achieved by additional means.

A Practical System

Up to about 6-mc carriers where the deviation does not exceed 1 mc, a multivibrator type of oscillator whose frequency is changed by applying video directly to its control grids seems to be satisfactory and is certainly the simplest so far as circuitry is concerned. Figure 1 shows the essential parts of the modulator.

Two 6CL6's serve as a multivibrator in which special consideration has been given to reducing the switching time, and the grids of the 6CL6's are driven by the 5687 cathode follower. The output of the multivibrator is amplified by conventional wideband amplifiers and then applied in parallel to the head driving amplifiers which consist of two 815 tubes.

On playback the signal from the switcher is applied to a wideband cascaded clipper and from there to the slope detector shown in Fig. 2.

The last stage of the clippers is coupled to a bifilar wound coil whose center tap is grounded. The coil is made to resonate at a frequency out of the passband and the skirt of the resonance curve is used as an FM to AM translator. The AM is full wave rectified and turned into video by the two diodes. The variable resistor is a balance control to equalize the rectified carrier components of each diode, which balancing reduces the severity of requirements on the output filter (not shown).

The resonant frequency and Q of the coil are carefully chosen for maximum linearity. Linearity has not so far been found a problem with the tape recorder.

Acknowledgment

The author wishes to credit his associate, Harold Walsh, who supplied much of the theoretical help and provided the broad background material that now forms the solid base upon which our methods rest.

Rotary-Head Switching in the Ampex Video Tape Recorder

By RAY M. DOLBY

The problem of commutation and switching for rotary-head tape recorders is not one which dictates a singular solution; rather, in the course of our investigations we have found many approaches feasible, in varying degrees, of course. Our purpose in this paper is to present an indication of what has already been accomplished in the way of a workable product, even if admittedly it is not to be considered the ultimate. However, the present form of the switching scheme may better be understood and appreciated if first a few of the less successful approaches, with their attendant merits as well as pitfalls, are reviewed.

Frankly, the fundamental problem is that the Ampex system uses four heads on a rotating drum. Practically, this means that the final r-f output signal is not continuous, but must be synthesized from portions contributed by each of the four rotary heads. In the early stages of the experimentation, switching between the various heads was not employed, nor was it deemed necessary until further information was gathered regarding frequency response, signal-to-noise ratio, and modulation schemes, as well as the mechanical considerations of tape guiding and head tracking on playback. Thus, as shown by Fig. 1, the experiments were made with all four heads wired in a series circuit, from which a common output was obtained.

With this arrangement there could be no audio track, of course, and also to avoid the use of a control track, a servo system was devised which employed the longitudinal magnetic components of the vertical sweeps on the tape. The radius of the head structure was designed to allow one head to enter the tape just as the previous one was leaving, and it was thought that a substantially continuous output signal could thus be realized. But it did not take long to discover that there was a serious interruption where the entering head began its track, due to tape slapping and to possible cancellations in the carrier signal.

Even before the initial experiments were complete it was obvious that switching the heads during an overlap interval would be imperative if continuity of output signal were to be obtained (Fig. 2). The first reaction might be that a mechanical slip ring switch would suffice; however, a brief arithmetic consideration will show that this is not workable. Specifically, the switching must be done within, let us say, 0.1 μsec, to be consistent with the desired bandpass of the system. A tenth of a microsecond, for a relative head-tape velocity of 1500 in./sec, represents 0.15 mils on the periphery of the drum. A suitable slip ring switch-

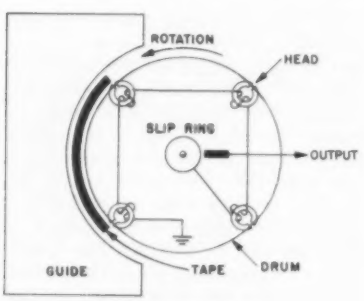

Fig. 1. The basic commutation technique.

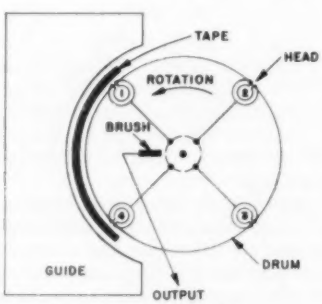

Fig. 2. Mechanical switching system.

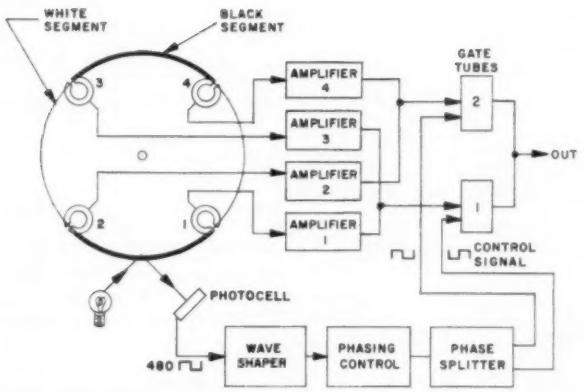

Fig. 3. Electronic switching system.

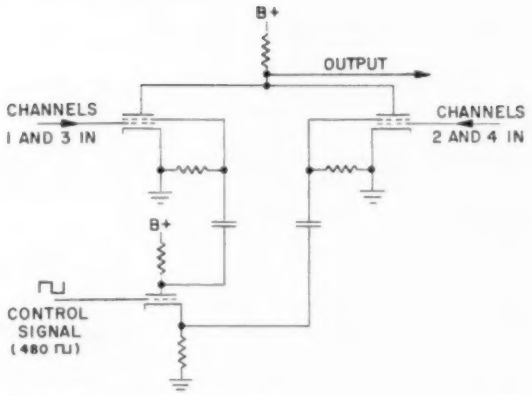

Fig. 4. Basic switching circuitry.

ing assembly would be approximately $\frac{1}{2}$ in. in diameter, for example, which means further that the distance in which the switching should occur must be about 0.04 mil on the periphery of this rotary switch. This is clearly a very difficult thing to achieve with known types of brushes, particularly when these brushes must have the necessary durability for high-speed operation.

The next approach which suggests itself is that of the electronic switch (Fig. 3). Possibly the simplest arrangement in this category would be the ruse of pairing two opposite channels, such as 1 and 3, and 2 and 4, so that it is necessary only to switch between the two paired channels to obtain a continuous output.

Gearing the switching time to the angular position of the wheel can be accomplished in several ways, including the use of magnetic pickups or photocells. Photocells have been found most satisfactory in obtaining the switching signal, as they have the advantage of being insensitive to magnetic fields, which the drum motor supplies in copious quantities. In addition, they also deliver a high output voltage in the order of 10 v peak-to-peak, so that amplifying circuitry following the photocell is relatively simple.

The wheel is painted alternately black and white in four segments. The output of the photoelectric cell will thus be two full square-wave cycles per revolution of the drum, which, in the case of the present speed of 240 rps, amounts to a square-wave output of 480 c (cycles per second). With apertures of the light source and photoelectric cell such that the resulting square wave has a rise time of approximately 100-μsec, a compromise is obtained between rise time and output voltage. The 100-μsec rise time, amounting to about one tenth the duration of a half-cycle, has been found quite satisfactory, since, even though the wave has ultimately a rise time in the order of 0.1 μsec or less, total phase drift can be held to a very few microseconds. Control over the timing of the switching process without resort to the awkward operation of repainting the wheel is obtained with a phasing control.

The controlling 480-c square waves appear in two polarities at the suppressor grids of the gates, which may be tubes such as 6AS6's or 6BN6's. These tubes have characteristics such that the suppressor grid must be positive (relatively) before the tube will conduct the signal applied to the properly biased control grid. The 6AS6 tube has a grid structure similar to that of a standard pentode, with the exception that a pronounced and easily controllable virtual cathode forms between the screen and suppressor grids. In effect, the virtual cathode, suppressor grid, and plate may be treated as a triode section with consequent excellent controlling characteristics by the suppressor grid. The 6BN6 is of different construction, being designed primarily as a limiter, but, like the 6AS6, it has good controlling characteristics due to what we can conveniently call the suppressor grid. Most linear operation has been obtained in both the 6AS6 and the 6BN6 by applying the incoming r-f signal to the control grids, and applying the switching signal to the suppressor grids.

Figure 4 shows typical circuitry. With control grid biases adjusted so that the d-c components of the plate currents will be the same for both tubes, the r-f output of the switcher is taken from the common plate load resistor. This two-channel switcher was acceptable until the signal-to-noise ratio began to be limited by the noise added by the channel opposite from the head actually sweeping the tape. That is, at any given time, signal is being supplied by only one head, whereas noise is being added to the output by two heads. Theoretically, considering wideband noise only, the resulting signal-to-noise ratio of the composite signal should be only 3 db worse than the ideal of having only one legitimate contributor at a time. Practically, however, a greater loss than this is suffered, since in many cases the noise amplitudes may add, as they would with a local powerful AM station being the noise generator (in which case the two noises could add in phase instead of at random).

Another baneful circumstance is that the outputs of all four heads may not be of the same amplitude, making consequent increase in the gain of the low channels necessary. The effect on the screen is that if the gain control on one of the preamplifiers were increased, more noise would appear in the band corresponding to the channel opposite from the one in question. A residual effect of this type is found even with FM recording.

Crosstalk, too, is another effect which plagues the two-channel switcher. The output from the head which is contributing signal may, in the head structure or in the associated wires and commutation means, be capacitively or otherwise introduced into the illegitimate channel. This output may add in irregular and unpredictable phase relation to that from the legitimate channel, to give a distorted resultant.

When it became known that the two-channel switcher was indeed a major contributor of noise to the overall system, a four-channel sequential switcher was devised. The advantages, of course, can be implied from what has been just said about the two-channel switcher; that is, one realizes fully independent control over the effect each channel has on the composite output. In order to accomplish the necessary sequential switching operation, various means could be employed. For instance, a binary count-down scheme could be utilized so that one revolution of the wheel would cause all four switching tubes to be energized sequentially. Another approach might be a triggered sequential multivibrator. However, with the disadvantage of instability, it might be difficult to insure that the heads will switch during the correct 90° interval.

The system which has now been worked out for use in the Ampex recorder overcomes some of the disadvantages of sequential multivibrators or count-down systems. Using a network of coincidence

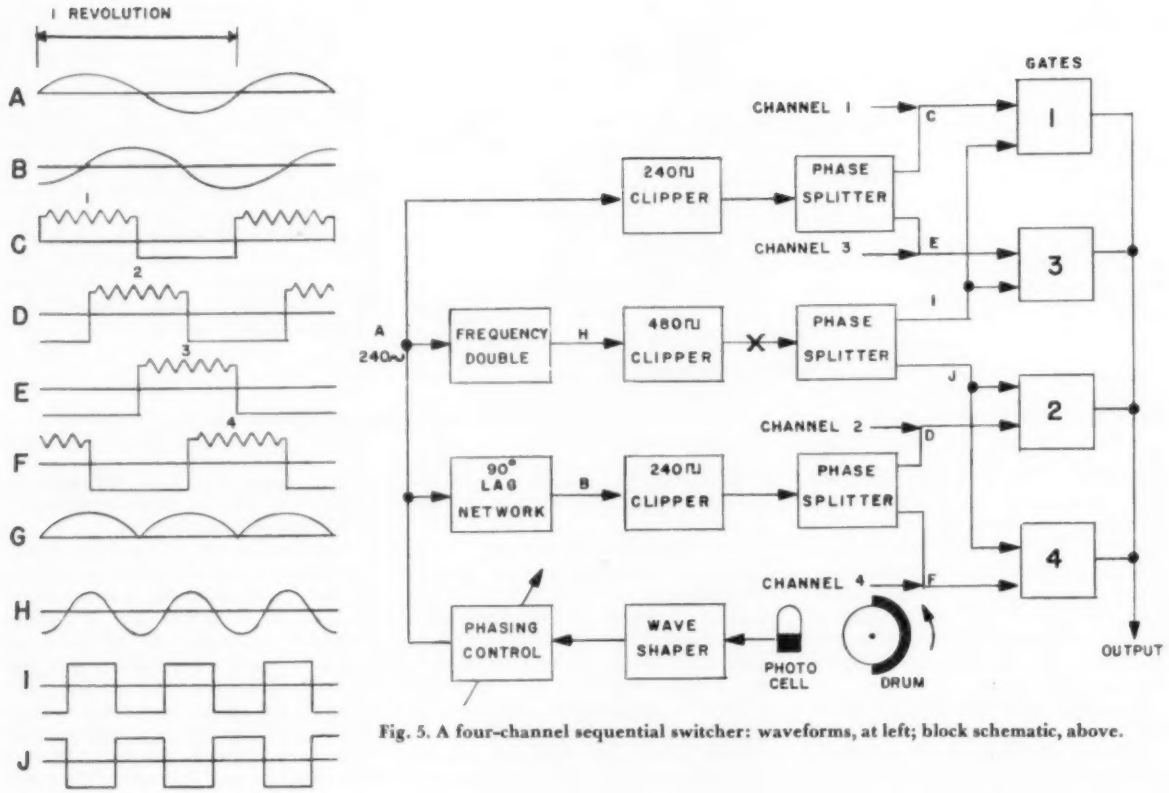

Fig. 5. A four-channel sequential switcher: waveforms, at left; block schematic, above.

gates, the present electronic switch is relatively simple, requiring, in addition to the circuitry used in the two-channel switcher, only two additional gating tubes and two dual triodes. The system is completely reliable; there is no chance for multivibrators or count-downs to get out of step and consequently turn on the right channel at the wrong time.

Painted in two segments under this scheme, the drum, together with the photocell, furnishes an output of 240 c (Fig. 5). By proper application to the four gate tubes of two polarities of 480 c, derived from 240 c, two polarities of in-phase 240 c, and two polarities of quadrature-phase 240 c, a sequential switching operation can be effected. When the positive-going portion of the 480-c signal is applied to the switch-tube suppressor grid and the positive-going portion of the 240-c signal plus the r-f is added to the control grid, the tube will conduct and pass the r-f signal to the plate circuit. If any other combination of the three waves is used the tube will not conduct.

The operation of this switcher possibly can best be explained by tracing the block diagram of Fig. 5 together with the waveforms appearing at the various points. In the lower righthand corner of Fig. 5 the photoelectric cell delivers a 240-c square wave to the wave shaper (a bandpass filter), and then to the phasing control. The 240-c output of the phasing control goes to three places, a frequency doubler, a 240-c "I" channel, and a 240-c "Q" channel.

The 240-c circuits will be traced first. The original 240-c signal A is fed to the 240-c clipper on top and then to the phase splitter, the outputs being seen at C and E, the r-f signals having been added also at these points. Channel 1 is fed to point C and added; channel 3 is fed to point E and added. In the other 240-c channel, the "Q" channel, the 240-c sine wave is fed through a 90° lag network, emerging at B, the waveform being shown at the second from the top of the waveform diagrams. As in the in-phase channel, the quadrature-phase channel is clipped in the 240-c clipper and fed to the phase splitter. The waveforms are seen at D and F. As with channels 1 and 3, r-f from channels 2 and 4 is added at these points.

As is suggested by the waveforms C, D, E and F, corresponding to channels 1, 2, 3 and 4, it would be necessary only to apply appropriate positive-going portions of 480-c square waves to the suppressor grids of these tubes in order to pass the r-f signal portions riding on the tops of the 240-c waves. The necessary 480-c signal is derived by means of a frequency doubler circuit in which the 240-c sine wave is full-wave rectified. This signal has a strong 480-c component which is separated by a tuned circuit. The resulting 480-c sine wave is then amplified and clipped. The waveforms corresponding to these operations are seen at G, H, I and J. The 480-c clipper symmetry is controlled so that, with the phasing control, the instant of switching can be adjusted with respect to the angular position of the heads on the tape. Final clipping of the 480-c square wave is done by a 6BN6 tube, reducing the rise time to approximately 0.05 μsec, and since it is the 480-c wave which executes the actual switching operation, there is thus very little interruption of the composite signal. One output from the 480-c phase splitter is fed to the supressor grids of channels 1 and 3. The other output, 180° out of phase, is fed to the suppressor grids of channels 2 and 4.

There is no bias, as such, on the suppressor grids of the switching tubes, as the signal is of large amplitude and either drives the tubes into cutoff or goes so far positive as to cause saturation current flow in the plate circuit so far as the suppressor grids are concerned. To provide proper bias for the control grids, the positive-going portions of the 240-c waves and their associated r-f signals are clamped to a negative bias voltage.

Now to follow the sequential operation through one complete cycle. The waveform diagram shows that at the control grid of gate 1, the r-f signal appears in the top central portion of the square wave, waveform C. Also the waveform I at the suppressor grid of this tube is seen to be

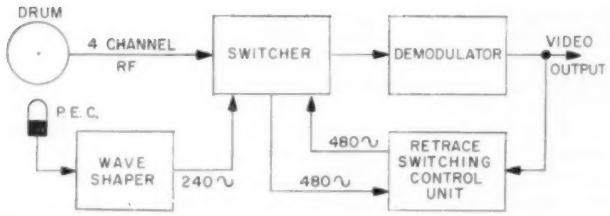

Fig. 6. Retrace switching system.

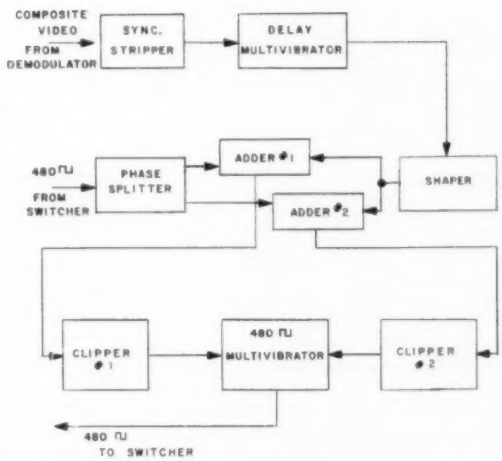

Fig. 7. Retrace switching control unit.

going positive a short time after the r-f signal appears at the control grid of gate 1. The 480-c square wave on the supressor grid, together with the properly biased signal at the control grid of the gate tube, causes the tube to conduct, the resulting r-f signal appearing in the common output circuit of all four gates. It can be seen that at the control grid of gate 2 the r-f signal next appears, waveform D. Waveform J at the suppressor grid of this tube is seen to be going positive shortly after the r-f signal appears on the control grid, and so gate 2 is energized. The reverse phase of the 480-c square wave simultaneously turns off gate 1 so that gate 2 is the only tube conducting. And so the switching goes through its sequence of all four channels and then repeats.

Up to this point there has been nothing introduced in the commutation or switching system, as well as the modulation system, that obligates the video tape recorder to be used in conjunction with a video signal. For example, if the video tape recorder does not have the best signal-to-noise ratio of any audio recorder known to date, it certainly has the flattest frequency response.

Finding the machine to be a rather prodigious audio recorder, we set up an even more interesting and ambitious task. An AM antenna was connected to a wideband preamplifier which was in turn fed to the standard 75-ohm input of the video tape recorder. The recording level was observed on the oscilloscope and adjusted to be the usual 1.4 v. The net consequence of the recording process was that the whole AM band was recorded intact, modulated on the FM carrier. With playback operation as usual, the output was taken from the demodulator 75-ohm output and fed to a standard broadcast receiver. Tuning could be accomplished up and down the band with no difficulty.

Some interesting sidelights came out of this experiment. The wideband tape recorder has a signal-to-noise ratio of about 30 db, by usual methods of video measurement. However, when the AM subcarriers are handled they may be recorded more than 40 db down with respect to peak recording level, and yet the resultant demodulated output after both FM and AM detection will be one which is easily recognizable. Of course, the answer lies in the bandwidth reduction effect which the AM receiver imposes on the signal. In only a 10-kc bandwidth the probability of noise appearing is correspondingly low. Indeed, multiple narrow channel recording is a technique which yet remains to be exploited.

Experiments were carried on for some time with the tape recorder in the form which has been described; however, when the signal-to-noise ratio of the system began to improve due to better electronics, better head construction, as well as smoother tapes, switching transients in the picture became more and more obvious. The spots, occurring in the form of little black and white dots on the screen, come from two causes:

(1) The first, and probably most obvious cause, is that of transients generated in the switcher. For instance, d-c currents in the sequential switching tubes may not be balanced, so that a sharp spike is generated in the r-f output. Also, capacitive coupling between the suppressors and the plates of the gate tubes may transmit some of the switching signal to the output.

(2) A more subtle defect lies in the possible change in carrier phase, switching from one channel to another. Let us say that the phase of the carrier in channel 1 may be 0°. The switch is then made to channel 2, in which the phase may be 180°, so that if a half-cycle is just completed in channel 1, the same half-cycle will again occur in channel 2. Interpreting this phenomenon as a sharp downswing in frequency, the demodulator delivers a black transient to the picture.

In the investigation of this effect, a rather interesting experiment was made. The output of the FM record modulator was fed to the inputs of the four-channel switcher, with the insertion of a variable delay line in one channel. By reducing the delay to zero, the switching transient can be made practically invisible on the screen. However, as the delay in the one channel is introduced, the transient begins to appear in greater magnitude as the delay discrepancy is made larger, until finally after 360° of delay, the transient disappears as would be expected. For a while, serious consideration had been given to the development of a super-fast electronic switch — that is, one which could complete the transition within 0.01 μsec. However, when the phase-shifting phenomenon came to light, it was apparent that a faster switcher would not be the way to effect a net reduction in the observed transients on the screen.

So another tack was made. Using characteristics of the data to be handled, one can reduce obvious defects in the reproduced signal to a minimum. Specifically, the retrace interval of the video waveform can be turned to good advantage by providing a handy camouflage for the switching operation. Unfortunately, however, this cannot be handled by causing the pulses always to be recorded in the same position on the tape — the last pulse in any sweep appearing one-quarter inch from the bottom, for instance. Hunting of the drum in the recording process precludes such a seemingly simple solution.

The electronic artifice finally settled on is shown in Fig. 6. The method can be reduced to a "get ready — go" process which occurs in the retrace switching control unit. The photocell provides the "get ready" information, the sync pulses of the demodulated video output contributing the "go" signal.

Breaking the point marked X on Fig. 5, one obtains a 480-c square wave, subsequently sends it to the retrace switching control unit for modification, and then returns it (its offspring, more precisely) to the switcher where this wave performs the usual function of switching the signals.

A supplementary item in the video tape recorder, the retrace switching control unit may be put in and out of the switching operation at will. When tests are being made with sine waves or other

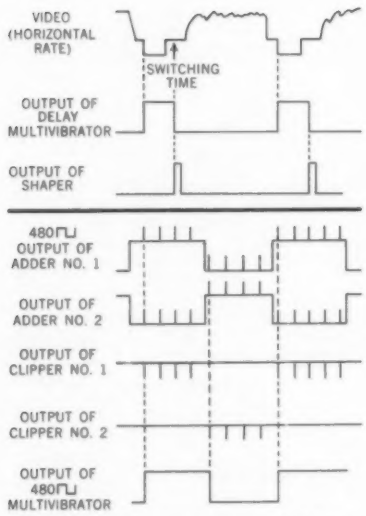
VIDEO (HORIZONTAL RATE)
SWITCHING TIME
OUTPUT OF DELAY MULTIVIBRATOR
OUTPUT OF SHAPER
480 OUTPUT OF ADDER NO. 1
OUTPUT OF ADDER NO. 2
OUTPUT OF CLIPPER NO. 1
OUTPUT OF CLIPPER NO. 2
OUTPUT OF 480 MULTIVIBRATOR

Fig. 8. Waveforms – retrace switching control unit.

nonvideo waveforms, the retrace control is usually out so that switcher is controlled only by the angular position of the drum, and is not related to the character of the signal coming off the tape.

Figure 7 shows in greater detail the operation of the retrace switching control unit. The core of the device is a 480-c multivibrator which is locked by the joint efforts of the photocell signal and the demodulated synchronizing pulses. The philosophy is that after the 480-c incoming signal changes in polarity, the output of the retrace switching control unit will flip over in response to the arrival of the next synchronizing pulse.

Video signal is obtained at standard operating voltage from the demodulator, the signal being amplified and sent to the sync stripper. Locked by these synchronizing pulses, a 15.75-kc multivibrator is used to provide a variable time delay, so that the exact time at which the switching operation occurs can be controlled over certain limits. That is, it has been found optimum to position the switching time so that it occurs on the back porch interval, which, as far as the picture is concerned, places the switching transients on the extreme lefthand side of the screen, just out of the field of view. This must be done with some accuracy, near the middle of the back porch, to prevent the transient from appearing on the retrace line.

Serving another purpose as well, the delay multivibrator, in the event of video signal failure, will continue to send triggering pulses to the 480-c multivibrator so that continuous output is obtained from the retrace switching control unit regardless of the nature of the incoming signal, video or otherwise. For example, if a synchronizing pulse should be missing from the train coming off the tape, and it is time for the switcher to move to the next head, the unit will wait an apportioned time and, with no synchronizing pulse in sight, will flip to the next channel of its own volition, resulting in no loss in signal from the tape. The output of the delay multivibrator is fed to a wave shaper, after which the pulses are added to two polarities of the 480-c signal. The two composite signals are introduced to clippers one and two, the outputs of which synchronize the 480-c multivibrator. The output from this multivibrator is injected back onto the main switching unit and is used to control the switching operation itself.

Figure 8 will clarify the exact nature of these wave-shaping operations. The top waveform is that of the horizontal rate of the standard video signal. The second waveform is the output of the delay multivibrator. The trailing edge of this output wave is differentiated and, as indicated in the third waveform, is the signal which ultimately controls the exact switching time. The two 480-c outputs of the adders are seen in the fourth and fifth waveforms. With the pulses derived from the synchronizing pulses superimposed on these waves, these signals are then fed to their respective clippers, emerging as bursts of triggering pulses. Of this series of negative-going pulses, approximately 2 μsec long, only the first is effective in locking the 480-c multivibrator. The multivibrator is synchronized in such a manner as to deliver to the output a signal always of the same polarity as that which has come in, except that the leading and trailing edges jump back and forth in discrete time steps of one line.

To illustrate the timing of various events, approximately 18 television picture lines are recorded per sweep, the net overlap on the tape from one channel to another being about two lines. Thus, the most desirable timing of the "get ready" signal, derived from the photocell, would be for its polarity change to occur one-half line after the overlap period starts. Then, after the readiness signal has arrived, the 480-c multivibrator is conditioned to accept the next synchronizing pulse which should come from the tape. This means that the switching operation conceivably could occur anywhere between one-half line and one and one-half lines after the beginning of the overlap interval. With a guard time of one-half line at the beginning and end of the overlap period, drift or maladjustment in the switching circuitry can be accommodated.

Subjective improvement of overall picture quality due to the use of the retrace switching control unit has been found to be fairly great, since no longer are the usual black and white specks due to the switching operation seen randomly coursing across the screen. Transition from one head to another through the use of the device is invisible.

Undoubtedly, more clever means of performing the whole switching operation can and will be contrived, but up to this time the devices of gearing the transition to the angular position of the rotary drum, as well as to the timing of the synchronizing pulses coming from the tape, have appeared to give satisfactory results.

Discussion

Leonard A. Herzig (Prestoseal Mfg. Corp.): Referring to the diagram of the 240-cycle interlock and your references about recording across the tape and then cutting out from 120° down to 90°, is there a special interlock on the reproduction end, one that allows the heads to be on for only 90° and on the recording end for 120°?

Mr. Ginsburg: No. During recording all heads are being fed current continuously. The amount of video-track information left on the tape after the tape has passed the control track and audio heads is slightly more than what has been written during 100° of arc. This leaves enough information overlap for the switching process which is accomplished during playback between consecutive head outputs. This will be covered in detail in a later paper.

Mr. Herzig: Is the width of the track 10 mils?

Mr. Ginsburg: It's approximately 10 mils.

Mr. Herzig: And the angulation of the track, actually, as it appears on the tape, is approximately what?

Mr. Ginsburg: Very small, since the tape travels 15 mils in 1 msec and the drum, during this time, is tracing out a path about 100 times this distance.

D. McCroskey (American Broadcasting Co., Burbank, Calif.): It isn't quite clear how you maintain perfect tracking on the playback process. Is it a function of the control system?

Mr. Ginsburg: We do not have to maintain perfect registration of the heads on the tracks. One of the principal reasons for using the special type of frequency modulation system employed is to make it unnecessary to have perfect registration during playback. Within limits which are met quite easily with this machine, the effect of tracking error is essentially undetectable. Several decibels of variation in amplitude of the r-f playback signal due to failure of the heads to register properly on the recorded tracks will result merely in the loss of signal-to-noise ratio. Very roughly, there is about a 1:1 correspondence between attenuation in db of the r-f amplitude due to tracking error and loss in signal-to-noise ratio as measured in the video output of the machine. A 20% tracking error would mean that the head is in its proper position with respect to the recorded track within 2 mils.

Mr. McCroskey: Does the spacing act as a guard band, then, to eliminate tracking two strips at once?

Mr. Ginsburg: Yes, we have to allow enough space so that the head can get as far off the track as it can get, still being able to make a satisfactory picture with respect to signal-to-noise ratio and at the same time not pick up the information on the next track.

Anon.: As to the ability of your system to make prints and, if you do make prints or duplicates from the original, what is the degradation?

Mr. Ginsburg: The degradation is extremely small. Nothing is lost in gray scale or in resolution. The only degradation that would occur would be in noise, but the degradation is small.

Don Wald (Univ. S. Calif.): This wheel that you describe, is that for black-and-white video? And, if so, what type of applications do you have to make for color? Do you have to increase the number of wheels or number of heads on the wheel?

Mr. Ginsburg: We're going to take, I believe, the same attitude with regard to talking about our color TV recording as we have taken in the past with regard to the development of the monochrome system. We aren't going to say anything about it until we have it finished.

A Multiple Magnetic Printing Equipment for CinemaScope

By
HANS CHRISTOPH WOHLRAB

A high-speed CinemaScope four-track sound printing equipment that produces six prints at the same time has been developed by the Klangfilm Division of Siemens & Halske A.G., Karlsruhe, West Germany, to meet specifications of DeLuxe Laboratories, Inc., New York. The printer operates at a speed of 135 ft/min, and, serviced by two men, has a printing capacity of 30,000 ft/hr.

THE RAPIDLY increasing number of motion pictures produced on CinemaScope required devices especially designed for quick printing of the four magnetic soundtracks. The essential demands in this equipment are high speed, reliability of the components and features for quickly isolating and clearing troubles, besides the self-evident attribute of high and constant quality. The equipment described here consists of four different parts: the master re-recorder; the printer; the monitoring rack; and the Rotosyn System.

(1) The Master Re-recorder

The Master re-recorder and the Printer (Fig. 1) are similar in construction. They consist of an upper part (the film-running device), and a lower part which is an amplifier rack cabinet. The rack itself is designed with swing-doors so that the rear side of the amplifiers is accessible, even during operation, for testing and measuring purposes.

The playback head, shown in Fig. 2, contains four single heads of 80 mh each with a gap of 0.4 mil and a laminated iron core of 6-mil mu-metal sheets.

The flywheels on the two drums are of different size (Fig. 6) and the one with the higher inertia has a special starting device operated by a motor, which is automatically controlled by the left filter lever. This lever, pulled by the film toward the left after the start of the driving sprocket wheel, controls the flywheel starter motor. As the flywheel comes up to synchronous speed, the strong pulling force of the film is released, the left filter lever swings to its working position and releases the switch which stops the flywheel starter motor and from this moment the flywheel runs freely.

Four pushbuttons at the left of the playback part (Fig. 3) control the Rotosyn System (see Sec. 4 below) and the motor for rewinding the master film at a speed of 2000 ft in 75 sec. Six signal lamps indicate which printer is ready for printing and connected to the Rotosyn power supply line, and a resettable footage counter shows the amount of film passed through the master and the attached printers.

In the lower part of the Master Re-recorder (Fig. 4), there are four scanning amplifiers, four variable scanning loss equalizers and four 34-db amplifiers for raising the signal voltage to about 500 mv at the distribution point, to which the inputs of the 24 recording amplifiers are connected.

All amplifiers are designed as cassette amplifiers of the slide-in type (Fig. 5.) Thus, they are easily changeable in case of trouble. Besides the four preamplifying channels, there are two more amplifiers in the fourth-track circuit. One of them amplifies and rectifies the 12-kc signal from the master track which, on this equipment running at 1.5 times the normal speed, becomes an 18-kc signal.

Presented on April 21, 1955 at the Society's Convention at Chicago by Harold Freedman who read the paper for the author, Hans Christoph Wohlrab, Siemens & Halske A.G., Karlsruhe, West Germany; Dr. Wohlrab is now with Bell & Howell Co., 7100 McCormick Rd., Chicago, 45. (This paper was received on March 7, 1955.)

Fig. 1. Master re-recorder (center) surrounded by six printers at DeLuxe Laboratories, Inc., New York.

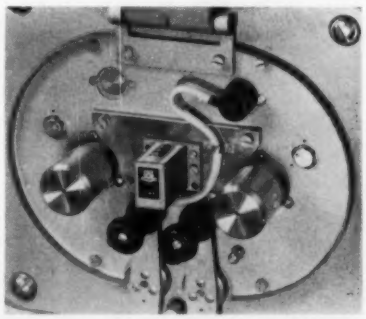

Fig. 2. Master re-recorder, playback part.

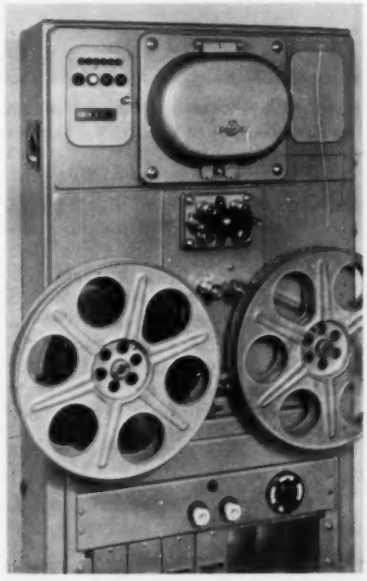

Fig. 3. Master re-recorder, upper part; film threaded for rewinding.

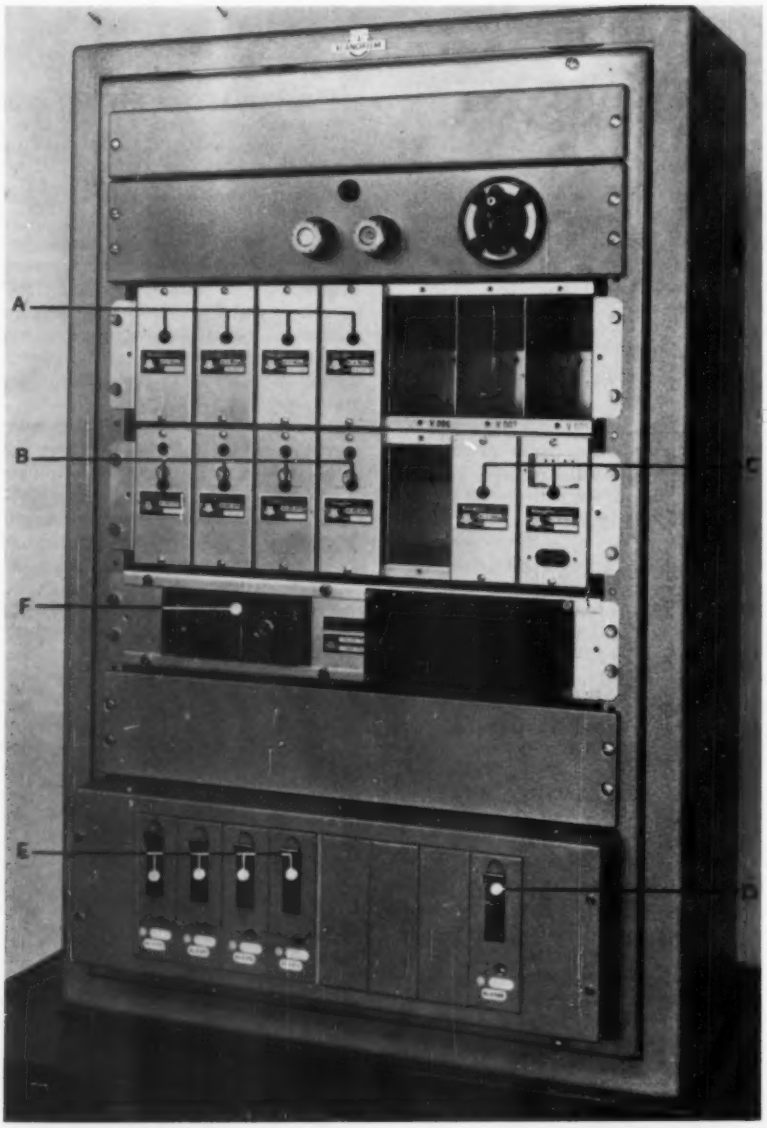

Fig. 4. Master re-recorder amplifier rack cabinet: A, scanning amplifier; B, scanning loss equalizer; C, 18-kc signal regenerator; D, 18-kc oscillator; E, 34-db amplifier; F, power supply.

Fig. 5. Slide-in type scanning amplifier.

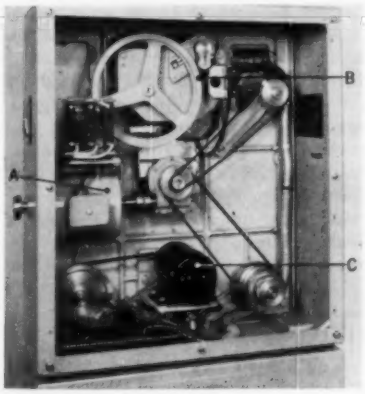

Fig. 6. Master re-recorder, rear view: A, synchronizing drive motor; B, flywheel with start-help motor device; C, rewind motor.

The direct current from this rectified signal controls a relay in the other amplifier cassette which feeds a new 18-kc signal, generated by a special 18-kc quartz oscillator, into the fourth-track circuit. On the other side, the original 18-kc signal from the master track is suppressed 60 db by means of a filter network to avoid any interference with the new signal. Figure 6 shows the rear view of the master re-recorder.

(2) The Printer

The printer, similar in construction to the master re-recorder, has two types of magnetic heads for CinemaScope release-print tracks. Each one of the four recording heads has an inductance of 7 mh, a gap of 0.4 mil and 4-mil mu-metal sheets in its laminated core. The monitoring head has the same electrical characteristics as the master playback head.

As shown in Fig. 7, the film runs from the righthand reel over an idler roller, a fixed special steel stud for burnishing the striped track and a 32-toothed sprocket wheel to the recording and monitoring part, which is covered by a mu-metal cover while in operation to shield the heads against outside magnetic fields. The film passes symmetrically from this part over the left side of the same sprocket wheel, runs over another idler roller and is wound up by the take-up reel.

In the recording and monitoring part itself (Figs. 7 and 8) the film goes over the righthand undamped filter roller, the right flywheel drum, the two heads, the left flywheel drum and the left filter roller, which is air-damped by means of a graphite–glass dashpot.

There are no rewinding facilities on the printer, because the film is handed over to the inspection room after printing. A set of pushbuttons on the upper right side enables the operator to connect the printer to the Rotosyn line or to disconnect it, the red lamp showing the "on-line" state. At the same time that the printer is on line, the corresponding yellow lamp on the master control board lights up.

On the amplifier rack (Fig. 9) there are four bias amplifiers, amplifying the 80-kc bias from the oscillator mounted in the monitor rack. Besides these, there are four recording amplifiers with variable volume and equalizing controls and two power supplies.

The monitoring heads are connected to the scanning amplifier by means of four black pushbutton switches which permit selection of any one of the tracks for monitoring. The output of the scanning amplifier goes to a relay in the monitoring rack which is controlled by the white button on each printer. Thus, each track can be monitored separately

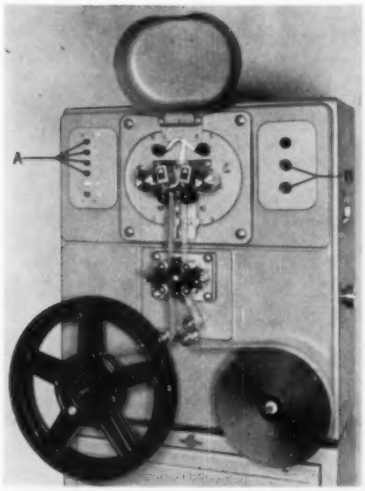

Fig. 7. Printer, upper part: A, monitoring pushbuttons; B, pushbuttons for connecting to the Rotosyn power line.

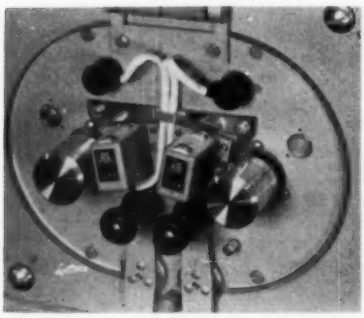

Fig. 8. Printer, recording and monitoring part.

by operating this control-button device. The monitor rack is shown in Fig. 10.

(3) The Monitor

The main monitoring amplifier and the relay panel for executing the above-described switching operations are mounted in a smaller swing-door rack. Six signal lamps show which one of the six printers is on the monitoring line.

The 80-kc bias oscillator is installed in the same rack. Because the most detrimental harmonic in the bias current is the second one, the whole bias circuit is worked out in push-pull: the oscillator itself, the step-down stage to the 24 amplifier inputs and the amplifiers themselves. Thus, it was possible to reduce the second harmonic to 72 db below the fundamental oscillation.

(4) The Rotosyn System*

Quite a new interlocking system has been used to give a guaranteed synchronous start or stop to the seven film running devices.

* See Karl G. Schwarz and Helmut Watzinger, "The Rotosyn System," *Siemens-Review, XX, No. 2:* 64–70, 1953.

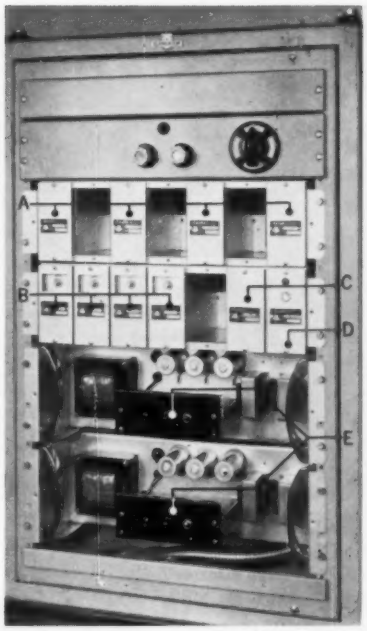

Fig. 9. Printer, amplifier rack: A, 80-kc bias amplifier; B, recording amplifier; C, monitor scanning amplifier; D, monitor scanning loss equalizer; E, power supply.

The master re-recorder and the printers are equipped with normal squirrel-cage synchronous motors without any special wiring or sliprings.

The Rotosyn Converter (see Fig. 11) only starts and stops the connected motors synchronously switching them over to the main three-phase line after having reached synchronous speed or taking them over from the main line to bring them down synchronously. During the whole printing process the equipment runs from the main power line, and the Rotosyn System is available for starting another set of printing-equipment motors, or a projector with separate soundtrack, or for whatever other purposes may be indicated.

The principle of the system may be described as follows: There is one converter fulfilling two different tasks. It has a 3-phase rotor winding and a 3-phase stator winding. Feeding a 60-c (cycles per second) voltage into the rotor over three sliprings, there will be induced in the stator a 60-c voltage, while the rotor is not in motion. Turning the rotor against the field, the frequency induced in the stator will become the difference between 60 c and the turning speed, reaching the frequency of zero at synchronous speed and, of course, at this speed no voltage will be induced in the stator. This means that as the converter is accelerated the stator voltage and frequency will decrease to zero.

Additionally, the rotor has a second winding system connected to a three-brush commutator. On the brushpoints

Fig. 10. Monitoring rack: A, relay panel with 6 signal lamps; B, power amplifier.

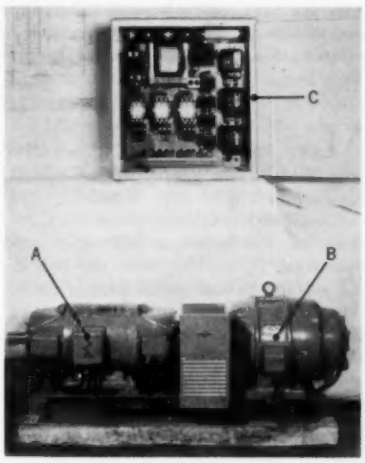

Fig. 11. Rotosyn Converter: A, 5-kw converter; B, brake motor; C, relay box.

of the commutator there will be a 60-c 3-phase frequency and a certain voltage when the converter is stopped. As the converter accelerates, the voltage on the brushes remains constant as the frequency decreases to zero. This means that the rotating field stops at the sync moment, maintains constant voltage, or in other words, the 3-phase a-c field becomes a 3-phase d-c voltage, the current in the 3-phase circuits being dependent upon the phase at which the rotating field stopped.

Adding these two voltages — one induced in the stator, the other from the commutator — by a series connection, there is a resulting voltage of about 70 v at frequency zero (d-c interlocking the motors before starting) and 220 at 60 c. This means — considering that the motor resistance increases with increasing frequency — that the motor current, the value of which defines the steadiness of synchronism, is constant from start to synchronous run.

The righthand motor on Fig. 11 is only a braking motor to stop the converter quickly when the equipment motors have to start.

Special relay circuits enable the operator to control the Rotosyn System by simple pushbuttons and provide safety arrangements in case of wrong operation.

The above-described printing equipment has been designed to be flexible in its performance. More or fewer printers may be used, as the equipment, once installed, can be enlarged by adding printers. This provides the opportunity to meet the varying demands of different studios or laboratories.

Fader Control for Continuous Printers

By GARO W. RAY

A device has recently been developed for the production of short and long fades and dissolves. Designed for automatic operation in conjunction with continuous printers, this experimental model also registers light-change information.

MANY PRODUCERS and laboratories have avoided the simple optical effects of various-length lap dissolves and various-timed fades on 16mm film because of the technical difficulties encountered. In working with the Bell & Howell and similar continuous printers, experience has shown that the requirements of printing plus timing the print in almost total darkness have engendered serious, almost insurmountable problems in producing such various-timed fades and dissolves. Our work at Ciné Video taught us that almost any continuous printer equipped with a fading device was depending upon the initial setup, invariably confined to a single length for any dissolve or fade on any particular print. Our urgent need for making long and short fades and dissolves led to the engineering design of a piece of equipment which by supplying various-length fades and dissolves increased the service and versatility of the Bell & Howell and other continuous printers.

The automatic device, shown in Fig. 1, was designed to pick and choose long and short fades and perform these without the operator's control by having a registration board lofted in advance of a particular print.

By way of explanation, short fades refer to extremely short fades — not more than six frames — so that the consequent dissolve this fade produces appears as an instantaneous dissolve intended primarily to hide 16mm splices while providing simultaneously a pleasant picture transition. Long fades refer to those fades which range from a minimum of 16 frames to a reasonable maximum of 48 frames. For setting the length for these fades, a spoke adjustment is attached to a linear rheostat in series with the printing lamp. This rheostat is revolved by a torque motor-chain drive.

The normal notches of the negative, reversal for dupe or color positive which is to be printed actuate a primary relay in the unit at the same time that they key the light-change solenoid. The one connection needed between this fade-change unit and the printer is a single pair of wires, and a series pair between rheostat and the power source (in this case, a rectifier), for the printing light.

As each notch passes a signal to the primary relay, it sets in motion a telephone-type stepping relay within the unit. Depending upon how the registration board is lofted, the unit performs all of the intended operations; the pilot lamps indicate the notch-number of the film. Once it has been decided on which notch to begin an effect, the dial which controls the stepping relay is used to

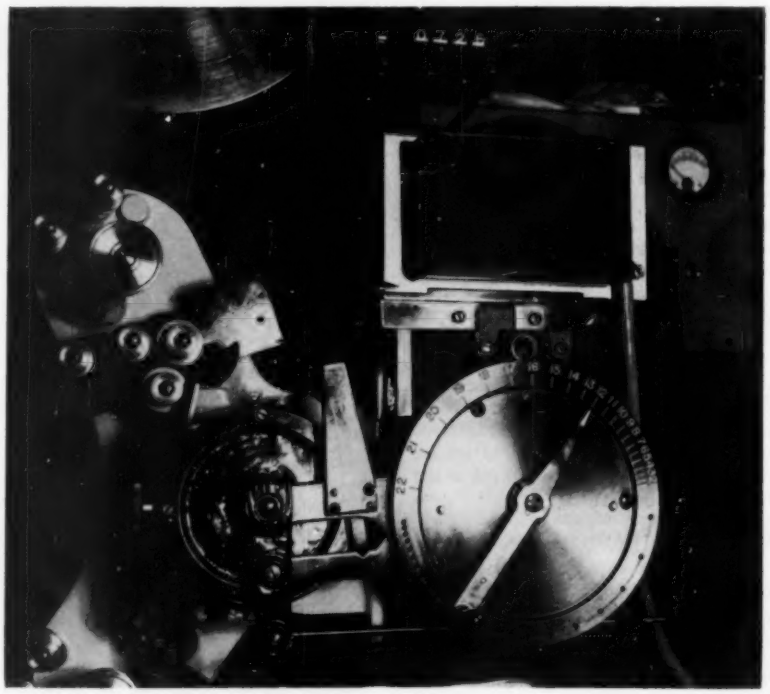

Fig. 1. Automatic device designed to pick and choose long and short fades.

A contribution submitted on March 4, 1957, by Garo W. Ray, Ciné Video Productions Inc., Boston Post Road, Milford, Conn.

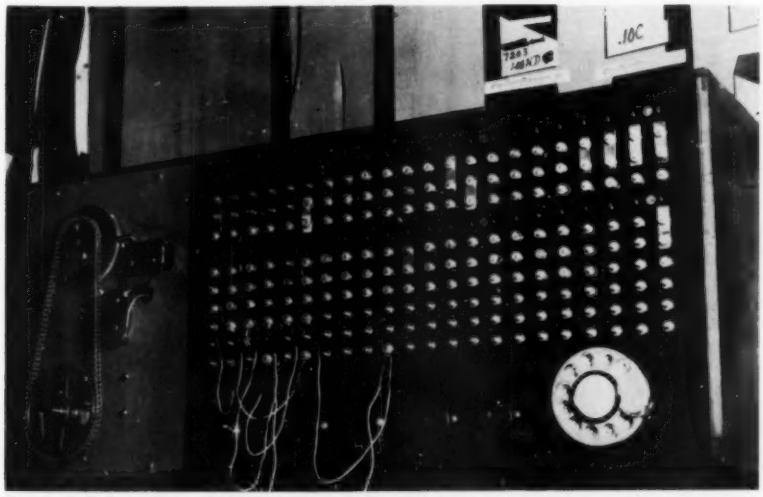

Fig. 2. Call board on which is indicated the anticipated light-change values for a succeeding notch.

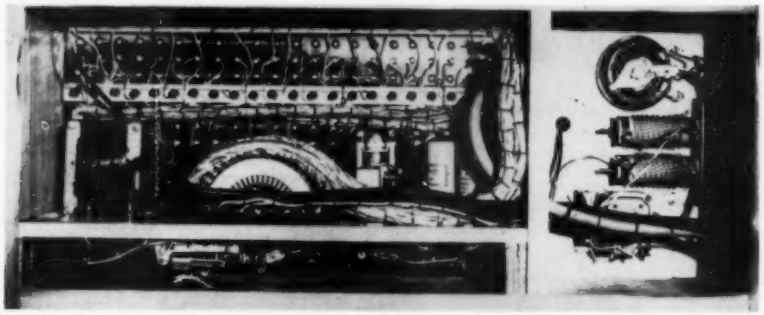

Fig. 3. Interconnections by means of which light-change numbers are transmitted on the call board.

summon that notch-number for insert printing. If a printer wants an insert which starts from a scene on notch-number 14, he dials to 14 and the unit is then ready to print all fades and dissolves, whether 6 or 16 frames, from notch 14 on without further attention from the operator.

When the stepping rotary switch responds to the various notches, the anticipated light-change value for the next notch is indicated on a call board (Fig. 2). This frame holds 22 lights in proper cells which by flashing in green on the front glass of the call board indicate the light-change information for the following notch-number. The call board slips into the place of the timing cards. Light-change numbers, prepared originally on a regular card for reference, are translated on the call board by means of the interconnections shown in Fig. 3.

Proper lofting occurs when all of the connections are made and all changes of light registered for a print with dissolves and fades. The operator, then, follows the dictates of the call board in adjusting his light-control, since the other functions are completed automatically.

A word about the interpretation of a 6-frame dissolve: This is a quick transition from picture to picture and the method of transition is contingent upon printing lamp-filament inertia. If a short 6-frame dissolve is needed, the control unit turns off the printing lamp, or turns it on, at the correct frame. Proper editing of A and B rolls insures accuracy, as editing insures all accuracy in printing.

The electronic department of Ciné Video Productions designed this unit as an aid for its printing department. The unit is intended to lend the time for care in the proper finish of simple productions made with A and B rolls. In providing fades and dissolves, spliceless scene changes, as well as controlled superimpositions, the unit has proved itself adequate and satisfactory.

(This system and equipment are to be briefly described, then demonstrated by a film at the Society's Convention in Washington, D. C., April 29–May 3.)

Spray Processing in a Commercial Laboratory

By RALPH D. WHITMORE, JR.

The design of this spray processor, four of which are now in full operation, using impingement drying, was based on both experimental data of the last two decades and operational experience gathered during the last two years. These are used for developing 16mm and 35mm black-and-white negatives and positives of all types at 80 F. The great versatility of the units, along with accurate sensitometry and chemistry, has increased both quality and volume in the laboratory.

SPRAY PROCESSING had its real beginning about twenty years ago. Definitive data did not become available until the early 1940's. Since that time a comprehensive, sustained study and application of this technique have resulted in an accumulation of information which encouraged Du Art Film Laboratories to undertake the bold step of converting entirely to spray processing of black-and-white 16mm and 35mm negatives, positives, masters, dupes, track and separations.

Many considerations militate in favor of this technique; when they are combined with impingement drying, we are of the opinion that the overall consequences improve product and service.

Turner and Jensen discussed spray processing principles at the Society's Lake Placid Convention.[1] Their recommendations coincide with the design details of the machines which are the subject of this paper.

Spray processing offers a number of advantages which substantially outweigh the disadvantages. Excellent uniformity of product is one of the more important. This is exemplified by identical results in processing in quick succession two H&D, or gamma strips, one head first, the other tail first. Close control of product is maintained through a refining procedure based on data derived from the continuous operation of this type of machine during the past few years.

Other advantages are a shortened processing time and a simplified mechanism, coupled with the ability to handle 16mm and 35mm black-and-white products of all types.

A shortened processing time reflects a saving in machine and auxiliary equipment costs. For the production of either 16mm or 35mm release-print material at a rate of 120 ft/min, the machine occupies a space $10\frac{1}{2}$ ft long, $2\frac{1}{2}$ ft wide and about 5 ft high. This capacity compares with immersion machines which are three to four times as large. Rental saving in lower floor area can be considerable. Floor loadings are substantially reduced. In these machines the liquid volume at any given time is not more than 5 gal in a cabinet, and with four cabinets this makes a total of 20 gal. Compare this with an immersion machine which may contain upwards of 1000 gal for a similar production capacity.

The present design of the machine embodies a multitude of features deemed essential to achieve the desired results — uniform high-quality product.

Two factors have a marked relationship to developing and processing time. These are temperature and spray or jet application of solutions.

The effect of temperature increase on developer permits a reduction in developing time. When combined with spray circulation, the decrease in time is more significant. The extreme is achieved in the so-called "hot" machines which process in the range of 100 to 150 F. In this range, the use of a prehardener bath is required for emulsions not able to withstand higher temperatures, or the use of the machine is restricted to those films which are prehardened in normal film manufacture.

An extremely short developing step makes control a more difficult and therefore more expensive procedure. The amount of time saved through an ultra-rapid process brings with it a diminishing return on the time-cost factor reflected in the difference of a "put-through" time of 20 sec vs. one of four to five minutes. This applies particularly to commercial laboratory conditions. It specifically excludes those situations in which time is an important economic factor. The units used at racetracks are an illustration of this point.

In this machine it was felt that a developing time of 1 min was a reasonable rationalization of the many factors considered. The chemistry of the developer was such that it was not necessary to use high-energy constituents. This is not to demean high-energy developers, and they have very definite applications.

A commercial motion-picture laboratory must be able to process any and all negative materials, including those emulsions which will not withstand elevated temperatures. Without making detailed reference to studies on the subject of ultimate temperature limitations, let it be stated that we established 80 F as the normal processing temperature. At the same time we regard 68 to 70 F as "cold" processing. This temperature also differentiates "hot" processing carried on at levels above 90 to 100 F and as high as 150 to 160 F, which is used restrictively with prehardened negative emulsions.

Fixing and hardening are accomplished in cabinets of the same physical dimensions as the developer cabinets as shown in Fig. 1. This provides spray application of the hypo bath at the same temperature, 80 F, and for the same length of time. The same situation holds for the washing step. The wash cabinets are also the same size as the other cabinets.

A significant factor which contributes to the small size of the machine and to the relatively short "put-through" time is the use of impingement drying.

The design of the drier was based completely on the data disclosed in the paper of F. D. Miller in 1953.[2] By a simple extrapolation of this information, a drying system was achieved that provided 45 sec of effective drying time (the time the film is opposite the air jets), when the machine is set at a speed of 60 ft/min. The temperature of the recirculating air is held at 140 F when processing negatives at this speed. When processing positives at 120 ft/min, the effective drying time is reduced to $22\frac{1}{2}$ sec, and the drying air is maintained at about 120 to 130 F.

It has been found that little make-up air is necessary beyond compensating for air lost through the film entry and exit slots. Evidently this is due in part to the fact that relative humidity in these temperature ranges is not significant. Miller pointed out that one of the more important factors in impingement drying is the velocity of the air at the film surface. Many papers have dealt with the removal of the layer of air immediately adjacent to the film surface, and the relation of drying time to the ability of the system to disperse this layer. In this sense, impingement drying is a cousin to the spray or jet application of solutions.

Because air impingement makes extremely fast drying possible, it is essential that all, and it is emphasized—*all*

Presented on April 30, 1956, at the Society's Convention at New York by Ralph D. Whitmore, Jr., Du Art Film Laboratories, Inc., 245 W. 55th St., New York 19.
(This paper was received on February 3, 1957.)

Fig. 1. The vertical cabinets from right to left are: Developer 1; Developer 2; Hypo; Wash; and Drying.

surface moisture must be removed. If not, the emulsion surface has either streaks or a "cratering" wherever droplets of moisture remain after the film has presumably been squeegeed.

There are a number of ways that surface moisture can be removed, most of which employ compressed air. Compressed air must be free of oil and water. There are a number of compressors which meet this specification.

The squeegee, shown in Fig. 2 and used on this machine, is one which was the subject of a paper by Ott and Lovick.[3] It is a highly effective and efficient squeegee requiring 8 to 10 cu ft/min at about 10 psi. It is aptly called a high efficiency squeegee. As insurance, this machine has two of these squeegees.

The machine utilizes a sprocket and elevator film transport system. The sprockets are a combination 16mm and 35mm stepped type with two 40-tooth 35mm sprocket inserts and one 22-tooth 16mm sprocket insert. The 35mm film is at a slightly greater pitch diameter than the 16mm film whose longitudinal axis is concentric to the 35mm but closer to the axis of rotation. The spools are molded nylon of the stepped type with the 16mm film riding on a base-supporting rubber tire which is clear of the track area regardless of whether "A" or "B" winding is transported. It should be pointed out that with this stepped concentric sprocket one must take care in loading 16mm of one or the other winding, depending on which side the 16mm sprocket insert is located with respect to film travel.

Each of the elevators in the spray cabinets has attached to it a simple rod extending through the top of the cabinet. This provides an easy means for checking elevator level during operation.

The loading section, separated from the processing and drying sections of the machine, is located in a darkroom. There are two let-off spindles and two banks of reserve which allow a maximum of 2 min at 60 ft/min and 1 min at 120 ft/min to splice on a new reel, thus permitting continuous operation.

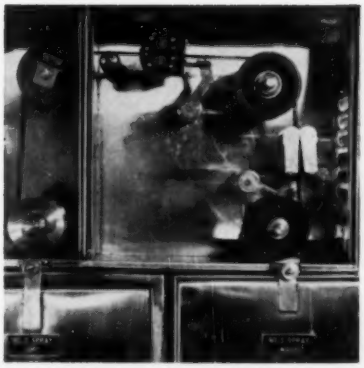

Fig. 2. The two Ott-Lovick Squeegees are shown in position along the film path between the washing and drying steps.

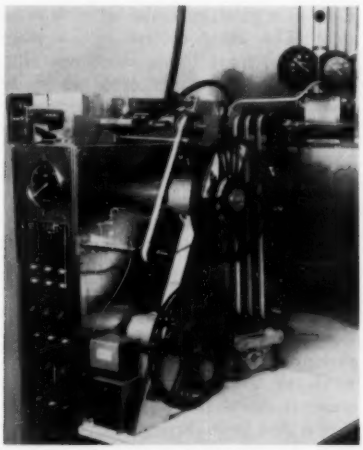

Fig. 3. Typical combination of 16mm and 35mm sprocket and spool, shown engaging the 16mm strand at the end of the machine.

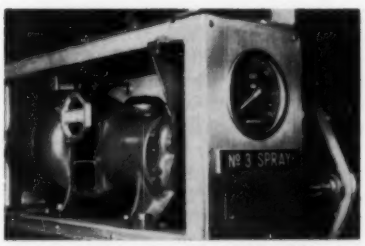

Fig. 4. The manually adjustable, infinitely variable drive located in the drier section adjacent to the control panel.

At the dry end there are two torque motor take-ups (Fig. 3). At the speed of 120 ft/min for positive, we have not found it necessary to have a take-off reserve elevator or accumulator bank. Figure 4 shows the variable-speed drive located in the drier section of the processor.

Film lubrication is provided for both 16mm and 35mm by moving an adjusting lever (Fig. 3). We have found silicone oil diluted in a volatile vehicle satisfactory for this purpose.

In changing from 16mm to 35mm or vice versa, it is necessary only to splice one to the other so that their longitudinal axes are concentric, then trim the edges of the 35mm to taper to the 16mm. The machine is then run normally. The only other adjustments are made by flipping a turret hold-down roller on the final sprocket and adjusting the waxer position.

As the 16mm film behind the 35mm film feeds into a film bank, the elevator rises until the 16mm film has engaged the sprocket in the next film back. The net result is less film in a film bank in a cabinet, but the actual time in a bath at a given machine speed is identical. The exact reverse occurs when converting from 16mm to 35mm film; that is, the elevators drop an equal amount successively, and the processing time remains constant. The changeover can be made in 5 min.

The small amount of solution in the cabinet makes it quite feasible to change a bath from negative to positive in a short time. There are only 5 gal/cabinet so that the loss in money is relatively small if one lets it drain. After draining, the cabinet is very quickly washed down and water is circulated by the system pump to clean out the components of the circulation system. This water is also drained and the new solution is then let in through the replenisher line.

At our laboratory, we have established a system of replenisher lines and tanks which makes possible a speedy changeover with a minimum of difficulty.

With the exception of water lines, replenisher connections, power and drain, the machine is completely self-contained. Each has its own drive, compressor, drying air blower, pumps, thermostats, thermometers, filters, heaters, switchgear, tachometer, replenisher metering, pressure gauges and pressure alarms. Figure 5 is a back view of the wash and hypo cabinets showing part of the individual circulation systems.

A secondary characteristic of the unit pertains to its simplified maintenance. The entire transport system is easily accessible for quick scrutiny and/or repairs as necessary. Similarly, all of the utilities on the machine are conveniently mounted.

The positive and negative formulae employed are made up of the usual constituents with no radical change in the ratios that may be considered as normal developers.

With respect to oxidation of the developing agents, it was found to be less a problem than originally anticipated. Oxidation occurs at a fairly rapid rate during the daily start-up period and in a short time the rate of oxidation stabilizes at a reasonable figure. The rate of oxidation is probably higher than the rate with immersion baths, but not high enough to create the need for any special precautions or consideration. Apparently what happens is that during the initial start-up, the oxidation takes place fairly rapidly until the oxygen content in the cabinet is reduced. No precautions to gas-seal the cabinets were made other than those necessary to prevent leakage of spray.

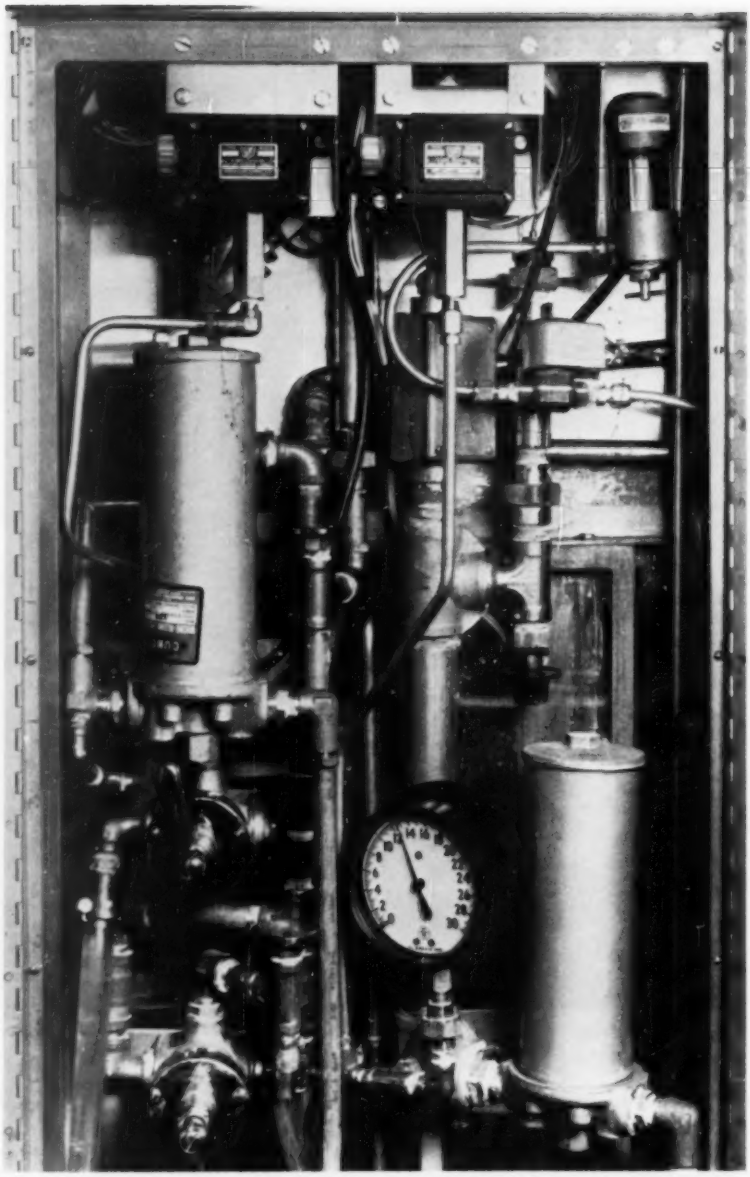

Fig. 5. A back view showing, at the left, the water blenders and filter for the wash cabinet; and at the right, the filter, heater, thermostat, Florator and gauge of the hypo system.

The fixing is accomplished by the use of a hypo mix which contains ammonium thiosulfate as its major component. Potassium alum is the hardening agent. Economically, the use of this hypo compares favorably with the sodium thiosulfate hypo. Silver recovery is carried on electrolytically as part of a closed circulation system with no difficulty experienced.

Wash water is constantly replenished at a rate of about 3 to 4 gal/min. Residual hypo is within commercial tolerances.

Sensitometrically we maintain the same conditions established in the immersion-machine operation. In fact, the gamma curves from the spray-processed H&D strips can be perfectly superimposed over those curves obtained in the

immersion machines. We have not tried to increase film speeds but have chosen instead to hold to the recommendations of the manufacturers. Cameramen, therefore, will not have to make any modifications in present lighting and camera-setting procedures.

(As part of the Convention presentation, the author included a film processed entirely, both negative and positive, on the spray processing machines.)

The writer has the pleasure of being the spokesman for a rather large group who contributed to the success of these machines. They are Messrs. Ralph Whitmore, Al Young, Robert Rheineck, Paul Kaufman, Edward Warnecke, Irwin Young, and Robert Young, who photographed the machine.

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2. F. Dana Miller, "Rapid drying of normally processed black-and-white motion-picture film," *Jour. SMPTE, 60:* 85–104, Feb. 1953.
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Integrated Design of Animated Film Equipment

By VERN W. PALEN

In developing equipment to meet today's requirements for animated film production, manufacturers have correlated the design of all components in order to achieve maximum accuracy, versatility and speed. The author describes the construction of such an integrated unit in detail and explains the operating advantages of the new mechanisms.

CLOSE COORDINATION of the functions of the stand, camera, stop-motion motor and compound table is the basic concept that has been used by John Oxberry in the design of equipment for animated film production.

From the outset, the goal has been to combine the best ideas of the past with unique new features that could be realized only by developing components which complement one another for maximum flexibility in overall studio operations.

Since production of animated films depends, essentially, on the accurate control over the movements of camera and artwork, this raised the question: which movements should be assigned to the camera and which to the artwork?

Sound engineering principles dictated that camera movements should be minimized since minor alignment errors are greatly magnified on the film. The Oxberry design confines camera movements to the vertical and allots all horizontal movements to the compound table top. This provides great latitude in mechanical design and opens up countless new avenues for the director in planning his animated sequences.

This paper discusses in detail the component parts of the animation stand installation (Fig. 1) and relates them to the work that must be performed by the operator. By incorporating many new features into the animation stand, camera, stop-motion motor and compound, it has been possible to provide endless working variations when the individual components are utilized together in one complete animation assembly. To assure perfect coordination between these integrated components, a series of special tests for the ground-glass reticle, follow focus and camera-carriage movement has been developed.

A contribution submitted on July 8, 1956, by Vern W. Palen, The Animation Equipment Corp., 38 Hudson St., New Rochelle, N. Y. A film showing the use of this equipment was shown on April 18, 1955, at the Society's Convention at Chicago.
(Revised paper received on February 12, 1957.)

Rigid Stand

Welded steel construction is used for the base of the stand, which measures 48 in. wide by 56 in. deep. Two 4½-in. diameter precision-ground steel columns are mounted vertically at the rear and are positioned side by side to provide strength, compactness and accurate camera alignment. Space between the columns is sufficient to allow artwork up to 24 in. wide to pass between them. Eight footpads are provided for critical leveling.

The complete stand requires a working space approximately 10 × 10 ft and floor-to-ceiling clearance of at least 12 ft, although shorter columns are available to fit any height ceiling. With full-height columns, the stand weighs approximately 1700 lb and handles zooms from 36 down to 3 field.

The camera carriage can be operated manually or by motor and it rides up and down to two sleeve castings having ball-bearing rollers. The rollers are mounted on eccentrics (Fig. 2) to permit free movement and no-play adjustment. Chain-connected lead weights suspended within the columns (Fig. 3) serve as counterbalances. A rigid faceplate on the carriage accommodates all standard cameras. A vertical square tube which may be rotated accommodates four field scales on which exact camera position is indicated by a pointer. A mechanical counter located at eye level registers all zoom positions in hundredths of an inch.

Auto Follow Focus

Cams, activating linkage and interchangeable lens barrels (Fig. 4) are included in the follow-focus mechanism. Installations are designed with 1, 2, 3 or 4 cams to accommodate 35mm or 16mm film sizes and to accommodate 47mm, 50mm, 58mm and 75mm lenses for 35mm film, and 25mm and 30mm lenses for 16mm film. Other lens choices are also available. It has been proven that the 47mm Ektar lens is very well suited for flat-to-flat work and gives excellent definition.

Cams are mounted at the rear of the stand and are approximately 5½ ft long. After a specific lens is selected, the cam is hand cut to match that particular lens. The cam-to-lens ratio is 3:1 which means that a 0.003-in. variation on the cam causes only a 0.001-in. movement on the lens. This is the maximum ratio that is mechanically practical and it provides more critical focusing. The mechanism is so sensitive that a piece of paper placed between the cam and trolley causes a noticeable change in focus.

The lens mount is fixed to the camera and provides a vertical, no-play, low-friction movement. Lenses are specially selected and fitted into interchangeable barrels for use with the animation stand.

Shadow boards are designed in two forms, each with side-hinged wings to

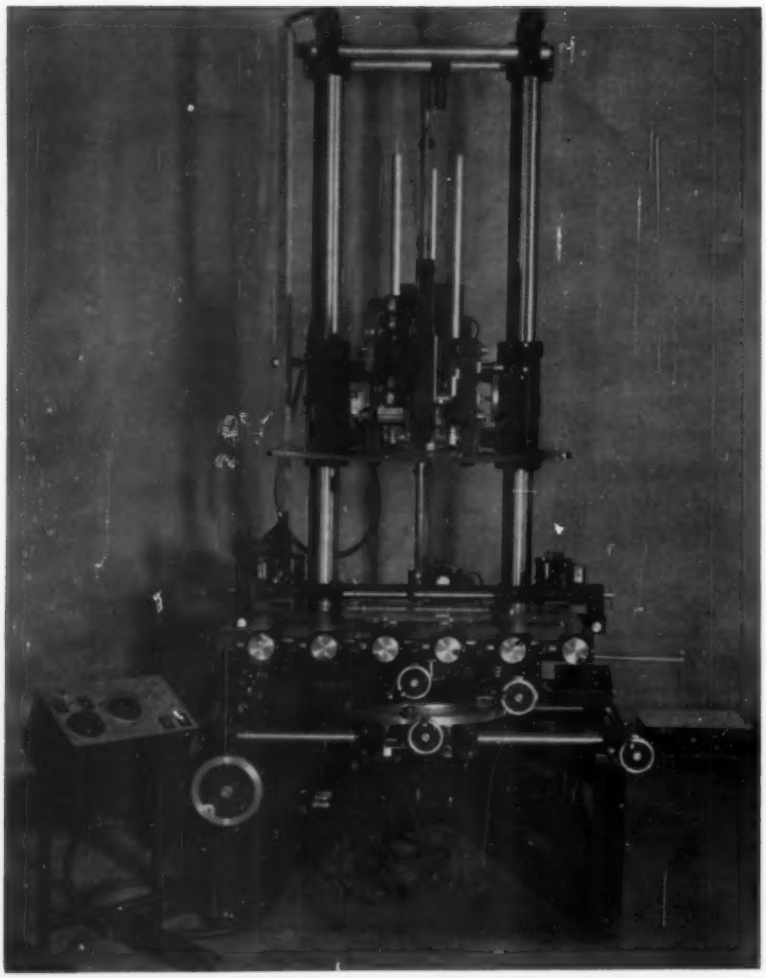

Fig. 1. Complete Oxberry animation stand and compound.

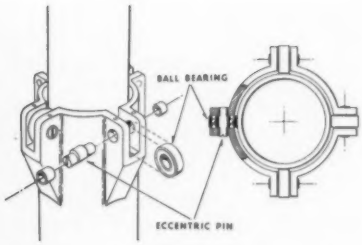

Fig. 2. Eccentrics used on camera carriage and table mounts. Bearing assemblies consist of three equally spaced ball bearings that roll on centerless ground tubes. Bearings are mounted on eccentrically ground pins.

prevent blocking of light when shooting a small field. One shadow board is small and square with a round hole in the center to provide a lens light path. The other, a larger shadow board, is geared so it can be cranked up and down and locked in any position. It contains an 8- × 10-in. aperture with an adaptor plate having a round hole at the center for the lens light path. This unit can be used for limited multiplane work and special effects such as wipes, ripple dissolves (with special glass), and similar tasks.

Motorized Zoom

An auxiliary d-c motor operates the camera carriage electrically and provides variable speed, quick reverse and stepless control, yet allows manual operation whenever necessary or desirable. The electric control provides smooth zoom action, regulated by rheostat and switches located on a separate console for convenient, finger-tip manipulation by the operator. The electric zoom minimizes the possibility of stroboscopic effect.

Electric operation of the camera carriage in combination with follow focus makes it possible to obtain a continuous automatic zoom with slow-in and slow-out movement. The old stop-motion, hand-crank and hand-focus method would take many more hours to do the same work.

A jog switch permits the operator to use the motorized zoom for stop-motion work instead of the hand crank. It allows the operator to move the camera carriage up or down any desired distance. By

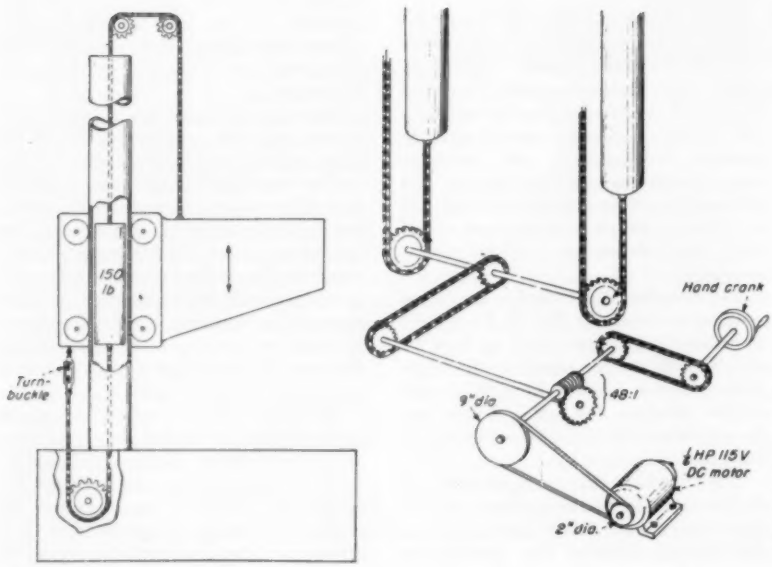

Fig. 3. Mechanical movements of camera carriage design. Two 150-lb counterweights inside the vertical columns permit the carriage to move easily, and an endless roller chain drive controls its position and speed. A counter driven directly from the chain serves as height indicator. For manual operation, one revolution of handwheel equals $\frac{1}{4}$ in. of camera travel.

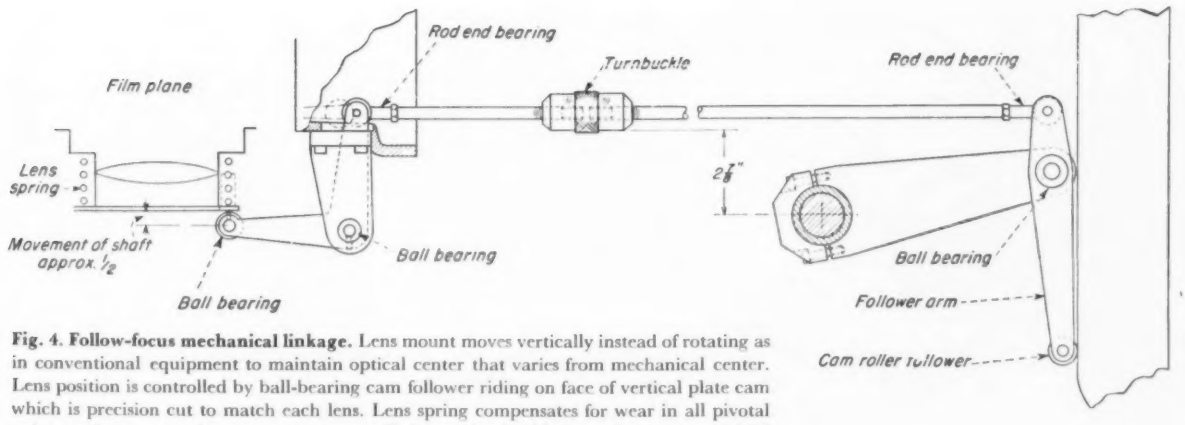

Fig. 4. Follow-focus mechanical linkage. Lens mount moves vertically instead of rotating as in conventional equipment to maintain optical center that varies from mechanical center. Lens position is controlled by ball-bearing cam follower riding on face of vertical plate cam which is precision cut to match each lens. Lens spring compensates for wear in all pivotal points and assures positive cam contact at all times. Turnbuckle is used to remove initial play in the mechanism.

setting the rheostat and observing distance on the zoom counter, the jog switch allows use of any desired portion of the field. Since it is used with an extension cord, it also permits the operator to adjust forward or reverse for a precise field while viewing from camera position.

New Camera Design

The Oxberry camera (Fig. 5) has been designed specifically for animation work and it incorporates a number of unique features. It has a rack-over mechanism for direct viewing and focusing. Normally, the camera is furnished initially for use with only one film size, either 35mm or 16mm. Accessories can be obtained at any time to accommodate either film size. Since critical alignment is very difficult to obtain when changing from a 35mm camera to a 16mm camera, the Oxberry design employs one basic camera housing for both film sizes. This housing remains in place on the animation stand—only the shuttles, sprocket assemblies, lenses and magazines are interchanged.

Shuttles

The shuttles (Fig. 6) are designed with fixed pilot-pin registration, the finest movement ever devised. The principle underlying this design is based on pilot pins which are fixed in their relationship to the aperture. With this construction, all movement is confined to the film, a condition that is vital for no-play and rock-steady pictures on the screen, essential for double exposure and matte work.

One feature is the special spring-loaded pressure plate which accommodates three films without adjustment. The loading of film is facilitated by a latched lift button which holds plates separated while the shuttle is being threaded.

Shuttles are constructed so the aperture can be changed quickly by removing four screws from the front, making it unnecessary to strip down the shuttle. A silent-film aperture is provided and it may be interchanged with accessory filmstrip apertures such as sound- or filmstrip apertures. The aperture socket is symmetrical and this allows 180° rotation of the sound aperture to place sound-on-left (animation direction) or sound-on-right (live-action direction). Each shuttle is machined from a solid-steel block and has a cast-steel yoke with hardened faces that engage the cams.

The entire cam shaft is cut from one piece of steel and it includes three cams and a worm. One heart cam comes into play when the 35mm shuttle is inserted; another heart cam performs a similar function when the 16mm shuttle is used. Shuttle forks are so placed that they pick up action from the proper heart cams whenever the 35mm or 16mm mechanisms are slipped into place. In operation, the action is as follows:

The barrel cam strips the film off the

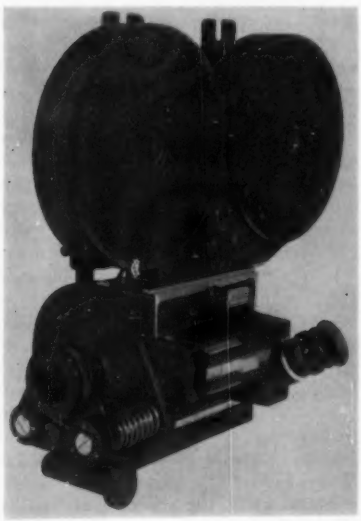

Fig. 5. Oxberry 35/16mm process camera.

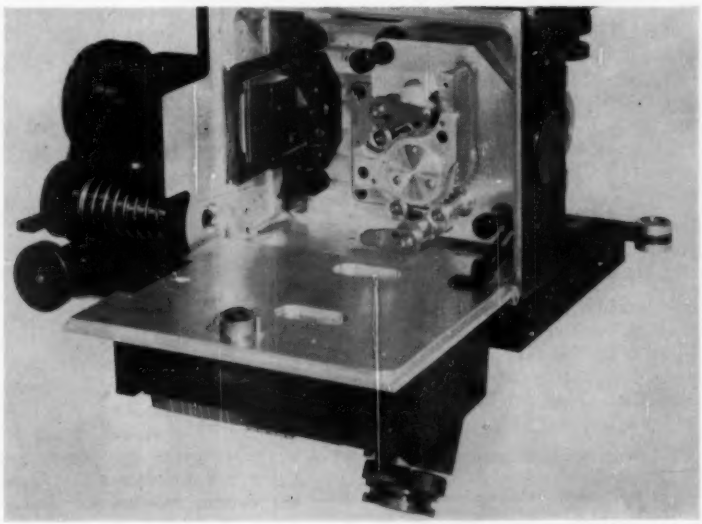

Fig. 6. Internal construction of camera.

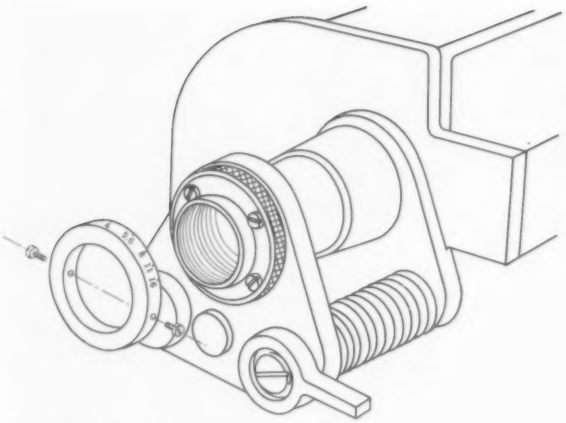

Fig. 7. Details of lens mount.

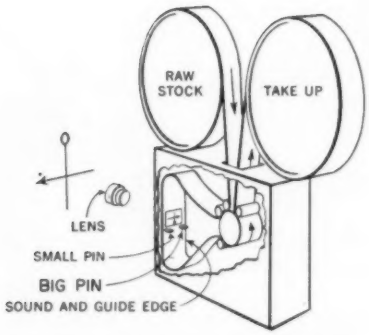

Fig. 8. How camera works for live action.

fixed locating pins and onto the carrier pins activated by the heart cam—this advances the film one frame. Then, the barrel cam comes into play again to strip the film from the carrier pins and place it on the fixed locating pins. During this cycle the heart cam brings back the carrier pins and the action just described is then repeated. The worm on the camshaft delivers motive power to the s procket assembly.

The fixed principle of confining the advancement to the film only, eliminates moving locating pins. Fixed pins are the only proven method for high precision process work. The shuttle mechanism is designed for speeds only up to 900 rpm.

Sprocket Assembly

Each sprocket mechanism is one complete unit—one is designed for 35mm and another, for 16mm film. Either mechanism is readily installed or removed in a few seconds merely by manipulating two thumb screws. A unique two-speed spindle is automatically engaged to provide the proper speed whenever 35-mm or 16mm mechanisms are inserted. The door of the camera will not close unless the sprocket assembly is in final locked position. Since sprocket assemblies can be removed completely, this feature permits the use of other accessories, described later in this paper under the heading *Projection and Rotoscope Work.*

Lens Mount

The Oxberry camera is engineered to take advantage of the minimum back focus. A lens may be placed as close as $\frac{1}{32}$ in. to the film plane. This permits the use of lenses as low as 30mm for 35mm film. There are three types of lens mount s available:

(1) Automatic focus mount;

(2) Calibrated hand-focus mount; and

(3) Bellows mount designed to do work from infinity to 1–1.

The automatic follow-focus mount is a spring-loaded, n o-p l a y, ball-bearing mechanism with a straight-line in-and-out movement which maintains the optical center precisely. This feature of the design is important because mechanical center of the lens differs from the optical center. The in-and-out movement permits this critical alignment to be retained under all focusing conditions. Built as an integral part of the camera faceplate, the follow-focus lens mount accommodates specified lenses for both 35mm and 16mm film. It can be disengaged so hand focusing can be used for special effects.

For manual (Fig. 7) focusing, two types of lens mounts are available: (1) For any lens for 16/35mm film, there is a special large bell housing calibrated from 3-in. to 36-in. fields on the perimeter. The 4-in. diameter of the bell housing permits the operator to sight field markings readily. It facilitates manual zooming and acts as a lens shade board. (2) To do work from 36 field down to 1–1 (1–1 cannot be done with automatic focus mount), a rack-and-pinion and bellows combination mount has been designed to meet special requirements. It is well suited to filmstrip work and special copying.

Rack-Over Design

Two rack-over systems are provided on the Oxberry camera. The first is a camera rack-over operated by a lever that activates a no-shock movement which positions the viewfinder directly over the lens. A safety rack-over switch cuts out the stop-motion motor except when the camera is seated in its shooting position. The second system is an indexing rack-over that is controlled by a dial which accurately shifts the camera to the correct location for sound-on-left, sound-on-right, or exact center. Sound-on-right 35mm location is when the camera goes forward for live direction (Fig. 8) in work with puppets and miniatures. Sound-on-left 35mm location is when the film is operated in reverse for animation (Fig. 9). Center camera location is for 16mm film or film strip.

Superimposure Viewing Device

The superimposure viewing device facilitates composing and focusing. The rack-over viewfinder with ground-glass focusing is mounted on the door. The eyepiece faces the operator when the camera is on the animation stand. An optical system rectifies the subject so the image is right side up and also permits copy to be read from left to right. The viewfinder has a special control which operates vertically. The up-position is for 35mm film and the down-position is for 16mm film. Normal magnification is approximately 4 ×. For 35mm film an additional magnification of $2\frac{1}{2}$ × may be obtained by placing the finder at the 16mm film position.

Reticle Feature

The reticle gauge is located at the bottom of the viewer and consists of a plate, pins and reticle. The reticle is mounted in a ground-steel dovetail slide. A compound adjustment provides for realignment when necessary. The superfine ground glass is precisely mounted and aligned in the gauge plate to match the film registration pins. In order to match the film plane, the eye picks up the image on the top ground-glass side of the reticle plate. This design compensates for the index factor of the glass in order to place the film at the proper film plane. This new feature permits a piece of film (such as a previously exposed and developed frame) to be placed on the top side of the ground glass on the fixed registration pins so that the operator views through the film first and then the ground glass, which is always fixed in relation to the pins.

Markings on the ground-glass reticles (Fig. 10) are essentially a series of rectangles. The progression from largest to

smallest is as follows: (1) silent aperture, (2) camera sound aperture, (3) 35mm sound-projection aperture, (4) dotted 25% TV cutoff aperture for 35-mm, (5) 16mm camera aperture, (6) 16mm projection aperture, and (7) dotted 25% TV cutoff aperture for 16mm. Reticles also have horizontal and vertical cross-lines common to all rectangles. A short tick line represents the center of silent 35mm or 16mm film.

The reticle gauge plate may be removed from dovetail camera slide for use as a visual gauge for viewing alignment and center or squareness of developed negative stock. By holding the reticle gauge over any light source, a film mounted on pins may be checked visually.

Special Critical Viewing

For supercritical lineup work such as traveling matte or checking alignment, the design provides a special cutout back pressure plate that may be removed from the shuttle. The feature of being able to remove the sprocket assembly and to remove a plug at the rear of the camera, permits a scope to be placed at this point (Fig. 11) and allows sighting straight through the shuttle aperture.

Magazines

Oxberry cameras are built to receive altered S-series Mitchell magazines, 400-ft, 1000-ft, and bipack, either 35mm or 16mm. The 16mm film size is symmetrically placed in the chambers of factory-modified 35mm magazines. All magazines are easily attached and removed.

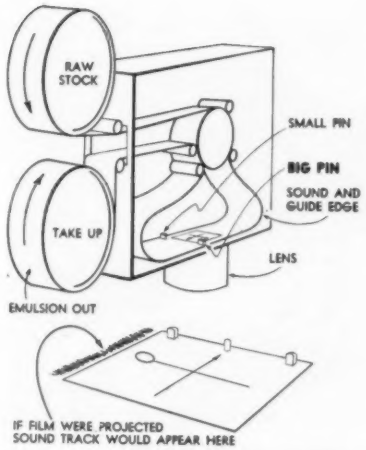

Fig. 9. How camera works for animation.

Automatic Take-up

The automatic take-up attaches directly to the camera and is designed with a torque motor on each of the four spindles. In operation, only two of the motors are energized, depending on whether the camera is moving forward or in reverse. The dead motors serve as drags or brakes and may be stalled without damage. The take-up is actuated automatically for either forward or reverse by the stop-motion motor switch. The design accommodates 400-ft, 1000-ft or bipack magazines of 35mm or 16mm film. Tension control may be adjusted for torque to compensate for variations of film such as from 200-ft 16mm to 1000-ft 35mm.

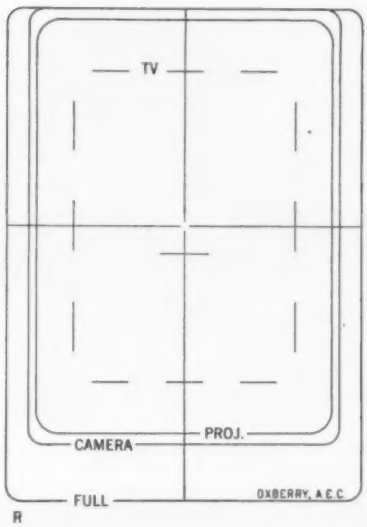

Fig. 10. Reticle markings.

Dissolve Mechanisms

A hand dissolve on the front of the camera has a progressive fade-in and fade-out scale calibrated in 16 frames and 24 frames for cross dissolves. This scale (Fig. 12) makes it easy to make mental calculations. The shutter may be set and locked at any designated opening such as $\frac{1}{4}$ shutter, $\frac{1}{2}$ shutter, etc. Shutter opening is 170° and is designed for precision stop-motion work.

An important accessory is the automatic dissolve which saves time and makes it unnecessary for the operator to leave his floor position in making a dis-

Fig. 11. How scope can be placed at rear of camera for sighting straight through the shuttle aperture.

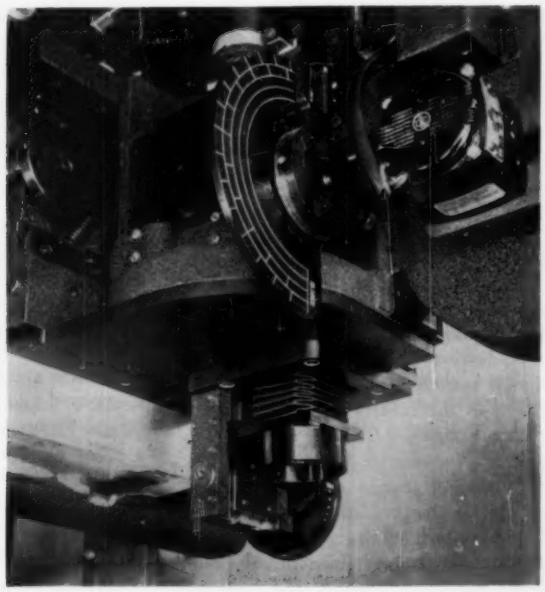

Fig. 12. Hand dissolve scale on camera.

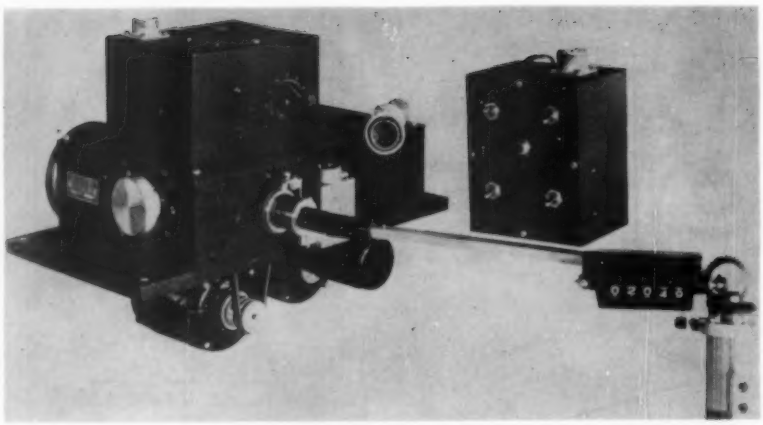

Fig. 13. Stop-motion motor, control box, mechanical linkage and counter.

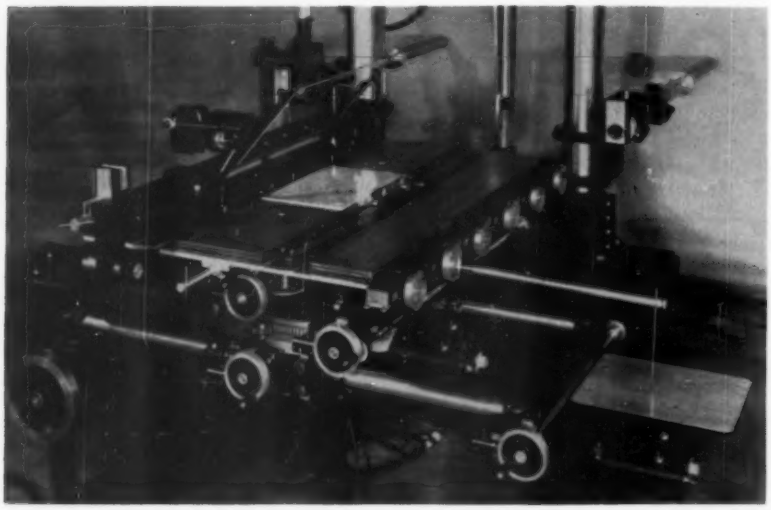

Fig. 14. Double-ring compound which permits diagonal pans with only one handwheel crank.

solve. It is operated through a dial selector on the side of the camera and has a range from 9 to 120 frames for a straight dissolve. The dissolve is actuated by an infinitely-variable speed unit to permit selection of 10, 11, 12 or any number of frames up to 120. Short dissolves have been in demand for TV work. A two-position switch controls and indicates shutter position as to cross-dissolve in or cross-dissolve out. Camera dissolve action is started by a control button located on the control panel. When the correct number of frames is exposed, the dissolve mechanism disengages automatically. A feature of the automatic dissolve is that one can stop motion a frame at a time with the shutter closing at its predetermined position each revolution or, in other words, one can stop motion on a frame with automatic dissolve engaged.

Projection and Rotoscope Work

The pressure plate of the shuttle with its removable cutout accommodates special projection work. A simple light and condenser assembly mounted on the open door may be used for traveling rotoscope work. This is used in conjunction with the stop-motion motor.

When a single frame is to be copied, it is placed on the 35mm locating pins of the reticle gauge. The rubber eye cap is removed and an accessory light is attached. When the camera is racked over, a 35mm film frame and reticle markings can be projected onto the table top for special artwork and similar applications.

Stop-Motion Motor

To meet today's demand for increased film production and lower costs, a variable, high-speed stop-motion motor (Fig. 13) has been designed of rugged construction in order to handle the tremendous shocks that shutter mechanisms must withstand. The innovation of an indexing stop-motion motor design provides multiple speeds with positive registration.

The stop-motion motor is readily attached to all standard cameras, either directly or through an adaptor. There are four speeds: 60 rpm ($\frac{1}{2}$-sec. exposure), 120 rpm ($\frac{1}{4}$-sec exposure), 180 rpm ($\frac{1}{6}$-sec exposure), and 240 rpm ($\frac{1}{8}$-sec exposure). This provides latitude for slow or fast film stock and for variations in lighting. A fifth rewind speed operates at 720 rpm. The synchromesh transmission has a dial for quick selection of the four speeds and they can be changed without stopping the motor. The four forward speeds permit a greater choice of lens stops and the 180 and 240 speeds save time on long continuous camera runs for titles and similar work.

Rapid changeover from single-frame to continuous operation is accomplished through a switch on the floor-mounted control panel. Another switch on this panel changes motor rotation instantly for forward or reverse operation. For stop-motion work, start, stop and rewind action is controlled by means of a foot pedal or by a pushbutton on the control panel. This makes it unnecessary for the operator to leave his floor position once the motor is set for the desired speed on the camera. When an operation demands only one stop-motion speed, the mechanical design permits ready conversion by elimination of specific gears. Thus, an installation may have a motor that provides 120 rpm with the option of fast (720 rpm) rewind speed.

Animation Compound

In the Oxberry design, the concept of the compound (Fig. 14) permits a complete selection of movements; north-south, east-west, and two rotating—with either manual or electric control. Provision is made for pantographs, up to six peg tracks, platens and a floating roll-away platen attachment.

Compound Construction

The compound table has a 28- × 34-in. working surface supported on 2-in. steel tubes, two extending north-south and two extending east-west. The table moves on these tubes by means of ball-bearing rollers. North-south movement covers a range up to 15 in., $7\frac{1}{2}$ in. on each side of center. East-west movement is 28 in., 14 in. on each side of center. With this arrangement, any type of diagonal pan is obtained merely by coordinating east-west and north-south controls in a predetermined pattern.

All movements may be controlled with hand cranks, locks and counters which read in hundredths of an inch. A hand lever disengages split nuts (Fig. 15) from

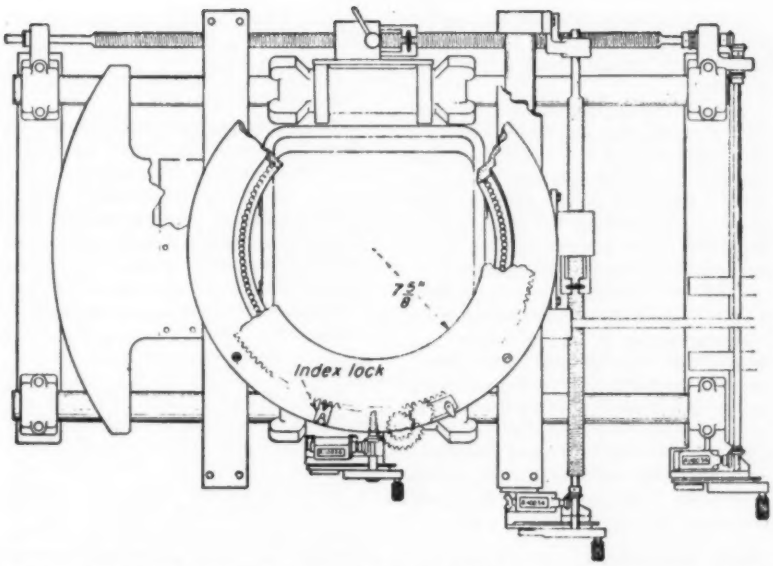

Fig. 15. Mechanical details of compound. Spring-loaded split nuts compensate for back lash on lead screws used to drive table in east-west and north-south directions for a no-play mechanism. Ball ring minimizes friction for rotation which is manually controlled. Drive is conventional worm gear unit through a counter so calibrated that one revolution of hand-crank equals one degree of table rotation.

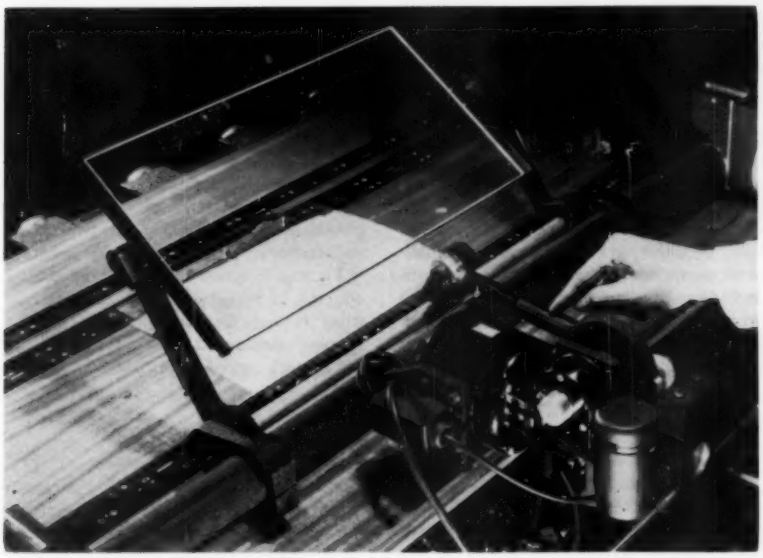

Fig. 16. Close-up of electric platen.

north-south and east-west lead screws whenever it is desirable to have the compound completely free for hand manipulation.

There are two types of compounds: one with a single-ring gear, the other with a double-ring gear. The first model has the single-ring gear mounted immediately beneath the table and it rotates 360° and has a counter, hand control and lock. The ring assembly is ball-bearing mounted and may be released for free spin. The table top may be turned to a 45° angle for special effects such as going up hill and panning up the face of a building. It may be turned 180° for titles, scrolls, elevator or other rising effects. Of course, a complete spin may be precision-made with a counter calibrated in tenths of degrees.

Where desired, the design provides a second geared ring between the upper north-south and lower east-west roller tube assemblies (Fig. 14). In this case, the east-west tubes remain fixed while the north-south tubes may be pointed in any direction through 360°. The function of the second ring is to make diagonal pans with only one handwheel crank. For such work, the bottom ring is rotated to the plotted diagonal. Then, the table top is rotated on the top ring so it is squared off and parallel to the camera aperture. This permits a single plotted diagonal and eliminates double plotting of east-west and north-south coordinates. The single hand crank diagonal movement gives a smoother live-action effect.

There are three different pantographs. The standard pantograph is designed to show north-south and east-west location of the compound in squared-off position. A second segment pantograph is used to indicate the rotated position of the top ring. The third type has been designed so the pantograph table top moves with the compound while the pointer remains fixed to represent the lens center. This facilitates following predetermined right-side-up guide.

Moving Peg Bars

Compound tables are assembled to meet user specifications with one to six peg bars, all of which have hand cranks, click stops, locks and counters that register in 100ths of an inch. A special mechanism compensates for backlash. The standard 4-digit counter has the number 500 at its center position and indicates either side of center by a number greater or less than 500. An alternate system has been developed, using a counter with top and bottom windows showing zero at the center position. The top window registers numbers in one direction; the bottom window registers in the other direction and a blind automatically covers the window that is not in operation.

Each peg bar accommodates a full set of pegs which are quickly removed and interchanged. Travel of peg bar is 16 in. each side of center. Two peg tracks are normally located at 12 field or at $10\frac{1}{2}$-in. centers. Inside tracks (adjacent to 12-field tracks with a 0.010-in. slot between to allow a razor blade to slit a cel) are frequently used to carry extra taped-down cels (sheets of transparent celluloid). Two additional tracks may be located at 18 field or at any other designated position on the table top.

A quick release and lock device has been developed for use with each peg track. On a long pan, it is possible to double the movement of the peg bar by releasing the mechanism and moving it back to zero without losing the counter number. An electric peg track with variable-speed control may be installed on one or two peg tracks. When the

compound is turned 90° this electric peg track is well suited for vertical scroll titles.

Platens — Stationary and Floating

Glass platens are for the purpose of holding cels in a flat position for shooting. There are two basic types, manual and electric, made for 12 field, 18 field, CinemaScope size, or other standards.

The 12-field manual platen has a ratchet with two stationary positions. The water-white glass is semi-gimbal mounted to provide a self-leveling action. It measures $9\frac{3}{4} \times 17\frac{3}{4}$ in. The complete platen is equipped with a hinged bar and adjustable mounting brackets which allow it to be attached or detached easily from the compound.

The electric platen (Fig. 16) is mounted on a hinged bar for rapid action and it has a foot control. A safety trip mechanism allows the camera to shoot a frame only when the electric platen is in a down position; there is a bypass switch cancelling the safety trip action. The entire bar and platen may be removed from the adjustable mounting brackets.

A floating platen roll-away attachment may be fastened to the columns as a ball-bearing member which can be rolled forward or back and away. This assembly receives both manual and electric platen hinge bars. Floating roll-away permits additional action for maintaining a cel background at a fixed position while the compound is moved independently.

Special Peg Plates

A fixed peg plate may be attached to the platen bar. This plate may be adjusted vertically to compensate for thickness of background. When the platen with the peg plate is removed from the compound and is attached to the floating assembly, the peg plate is independent of the table-top movement.

North-south and east-west movements may be attached to the manual floating platen on the stand to accurately control the action of a floating cel. These movements have cranks, lead screws and counters.

A flip-over peg plate has been designed with a set of pegs mounted on a plate which is anchored to the table top. The function of the flip-over peg plate is to make a fixed position available for field guide alignment and for backgrounds. When not in use, the pegs flip over into a recess to provide a flat table surface.

A thin tape-on peg plate, consisting of a set of pegs mounted on an aluminum plate, measuring $\frac{1}{32} \times 2 \times 10\frac{1}{2}$ in., has been designed to be very flat so that it can be placed at any desired angle on the compound or on the artist's work table.

Another special traverse (or micropan) track with lead screw, hand crank and counter has been developed for operators who desire to locate such a track anywhere on the compound table top.

Electric Table Controls

This is a feature that actually converts the compound into a moving stage. The technique permits labor and artwork economies and minimum cel changes to achieve a fast shooting operation.

Individual motor controls have been developed for north-south and east-west movements of the compound and these provide stepless variable speeds through control rheostats. A master rheostat on the operating panel is connected with all motors. This arrangement permits the operator to rotate the compound or move it north-south or east-west separately, or in all directions simultaneously by manipulating the interlock variable master control.

In addition, the master rheostat interlocks with the electric zoom carriage. All movements, or any two, may be preset and interlocked together. This allows the introduction of trimotion effects which give the impression of live motion by combining a number of image movements. Motor control is also furnished for rotating the table when the operator desires smoother action than that provided by the hand crank.

Underneath Lighting

For pencil tests, color work and special effects, provision has been made for underneath lighting. The compound has a 9- × 12-in. hole at its center which is normally covered by a wood removable section having a foam-rubber pad. Glass may be inserted in this opening to accommodate underneath lighting from a floor unit which includes five photoflood lamps and a blower.

Equipment Tests

There are two tests employed in checking the alignment of the stand and follow focus. One test proves the zoom accuracy for the entire stand structure. Projected cross-lines from the camera must stay within the thickness of fine-pencil cross-lines on the table top, from a 36 field to a 3 field, or the entire height of the stand.

The second test proves the accuracy of the follow focus. In this case, individual dots of a 120/in. screen on the table top must stay in perfect focus from a 36 field to a 3 field when viewed with a 200× microscope in camera position.

Summary

Integrated Oxberry design is effective in obtaining exceptional flexibility and superior results in all types of studio problems. Tests demonstrate the accuracy of an interlocked, precision mechanism that includes stand, camera, stop-motion motor and compound. Each one of the components contributes a share to the greater latitude available to the operator in planning and executing his animated sequences.

Figures 3, 4 and 15 are reproduced by courtesy of McGraw-Hill Publishing Co., from *Product Engineering*, "Low-friction, no-play mechanisms maintain precision in camera stand," pp. 164–166, Jan. 1956.

A New Color Intermediate Positive–Intermediate Negative Film System for Color Motion-Picture Photography

By H. J. BELLO, JR., N.H. GROET, W.T. HANSON, JR., C.E. OSBORNE and D. M. ZWICK

A new color film, Eastman Color Intermediate Film, Types 5253 (35mm) and 7253 (16mm), which is designed for making intermediate color positives and duplicate color negatives from Eastman Color Negatives, is described. The convenience of a single color material for the two intermediate stages is noted, and the application of this film to the preparation of reduced-size duplicate negatives for contact release printing is discussed.

The need for sensitometric control in the printing and processing operations is stressed, since this all-color system does not have the contrast adjustment available when three silver-image separation positives are used. Processing and printing instructions are given, and a method for prevention of Newton's rings during contact-printing is described. The effect of inadequately exposed duplicate negatives on tone reproduction is pointed out and a method of determining optimum exposure is discussed. Several applications of this new film to motion-picture production are mentioned.

MANY PHASES in the production of motion pictures in color require the preparation of a duplicate negative from the original camera negative. It is convenient to introduce scene-to-scene transitions, process photography involving still or traveling mattes, artwork, and other special effects during the preparation of the duplicate negative. Replacement of damaged camera negatives, or the need for more than one printing master calls for longer sections or even entire feature lengths to be made as an intermediate negative. To accomplish these aims, it is necessary that the duplicate negative have color characteristics which allow a duplicate print to be made, matching in quality a print from the original negative.

A system in general use for making duplicate negatives from Eastman Color Negative Film, Type 5248, employs three silver separation positives made on Eastman Panchromatic Separation Film, Type 5216, or more recently, Eastman Panchromatic Separation Film, Type 5235. These three positives are printed, in register, onto Eastman Color Internegative Film, Type 5245. This system, shown schematically in Fig. 1, has been used for several years to produce high-quality duplicate color negatives.

However, this separation positive–color internegative system is not well suited for the preparation of 16mm reduction negatives from 35mm camera negatives. Where negatives differing in size from the camera negative are required, the operation of printing three black-and-white positives, in register, while optically reducing the size of the image, is both difficult and expensive. Use of the "large-size" camera negative has intensified this problem, since theater release prints are generally smaller in size than the original large-size camera negative.

Another possible method for the production of prints through intermediate negatives was presented to the Society in 1953 by Hanson and Kisner.[1] This system, shown schematically in Fig. 2, employs an intermediate color positive material and an intermediate color negative film. The introduction of a single color film at both intermediate stages would greatly simplify the preparation of intermediate negatives reduced in size from the camera negative. Hanson and Kisner stated, however, "It is unlikely that adequate reproduction quality can be obtained with such a system at this time."[1]

Recent improvements in the color characteristics of dye images now make it possible to obtain satisfactory color quality in an all-color film system involving four films from negative to release print. As a result of these improvements, and in consideration of the added requirements being placed on duplicating methods, a single film is being manufactured which fulfills the specifications of both the intermediate color positive and the intermediate color negative stages of an all-color duplicating system. It is the purpose of this paper to discuss the characteristics and usage of this new color intermediate film.

General Description

Eastman Color Intermediate Film, Types 5253 (35mm) and 7253 (16mm), is an incorporated-coupler type of multilayer film, containing colored couplers similar to those used in Eastman Color Negative Film, Type 5248. The structure is shown schematically in Fig. 3. The upper, blue-sensitive layer contains a colorless coupler which is converted to yellow dye during development. A yellow filter layer prevents blue light from reaching the layers beneath. The next layer is green-sensitized and contains a yellow-colored coupler which forms a magenta dye during development. The residual, yellow-colored coupler becomes a mask to correct for the unwanted blue absorption of the magenta dye. The bottom emulsion layer is red-sensitized and contains a pink-colored coupler which is converted to a cyan dye during development. The residual, pink-colored coupler forms a mask to correct for the unwanted blue and green absorption of the cyan

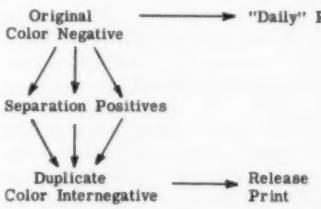

Fig. 1. Sequence of steps involved in making color prints by means of three separation positives and an intermediate color negative.

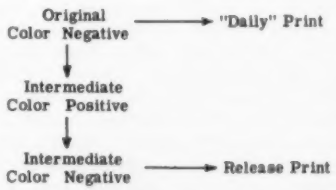

Fig. 2. Sequence of steps involved in making color prints by means of an intermediate color positive and an intermediate color negative.

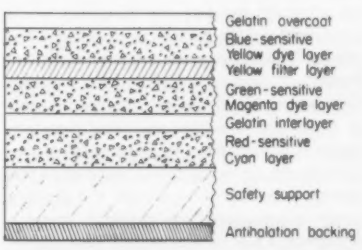

Fig. 3. Schematic cross section of Eastman Color Intermediate Film, Type 5253. All layers contain absorbing dye.

Communication No. 1888 from the Kodak Research Laboratories, presented on October 9, 1956, at the Society's Convention at Los Angeles, by N. H. Groet. All the authors are associated with the Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on March 4, 1957.)

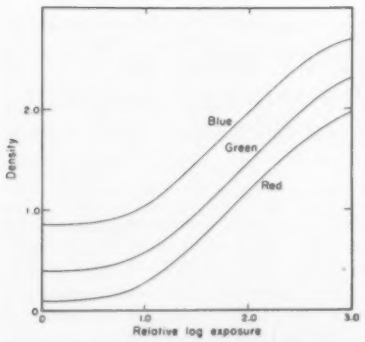

Fig. 4. Characteristic curve of Eastman Color Intermediate Film, Type 5253. Exposure: Intensity-scale sensitometer, 1/25 sec, 2850 K tungsten source, modified by Kodak Wratten Filter No. 2E, Corning Filter No. 3307, and Pittsburgh No. 2043X heat-absorbing glass (4 mm thick). Density: Integral, Eastman Status K Filters.

dye. This masking method has been described in more detail previously.[2,3]

Eastman Color Intermediate Film, Type 5253, also contains absorbing dyes which prevent scattered light from traveling significant distances in the emulsion layers. By this means, image sharpness is improved to a point where it is unnecessary to employ the inverted order of layers, with the accompanying inconvenience of unconventional sensitization-to-image color relationship that characterizes Eastman Color Internegative Film, Type 5245. These absorbing dyes are water-soluble, and are removed from the film during processing. A removable, black antihalation layer is coated on the back side of the support.

Film Characteristics

A characteristic curve of Eastman Color Intermediate Film, Type 5253, is given in Fig. 4. Here, density, as read on the Eastman Electronic Densitometer, Model 31A, with Eastman Status K Filters, is plotted against relative log exposure. The three curves, indicating density to red, green and blue light, are separated at zero exposure by the density contributed by the colored-coupler masks. The contrast of each layer is 1.0 when printing density is plotted against log exposure. Printing density is defined as the effective density one film has to its print film under specified printing conditions. This contrast of 1.0 is an essential feature of Eastman Color Intermediate Film, since this film is designed to be used in both the positive and the negative stages of the duplicating system. The useful latitude, or straight-line portion of the curves, is sufficient to record the density range encountered in original camera negatives made on Eastman Color Negative Film.

Film speed is low, and is of the order of one-third that of Eastman Color Print Film, Type 5382. Fine-grain emulsions are used to minimize the increase in granularity which accompanies duplicating, and also to make this film acceptable for 16mm duplicate negatives. Eastman Color Intermediate Film is color-balanced for printing from Eastman Color Negative Film, Type 5248, in conventional optical and contact printers used in color duplicating work.

Exposure of Eastman Color Intermediate Film

To ensure that Eastman Color Negative Film, Type 5248, has optimum printing contrasts when making the first, positive, intermediate stage, and to retain optimum printing contrasts when printing the second, negative, stage, it is necessary to control the energy at both ends of the visible-light spectrum of the printer light. The Kodak Wratten Filter No. 2E, which absorbs light of short, visible wavelengths, in combination with an efficient heat-absorbing glass, such as Pittsburgh Glass No. 2043X* (air-tempered), 4 mm thick, is optimum for this purpose, and these two filters should be used in all printers and scene testers when printing onto Eastman Color Intermediate Film from dye images.

Intermediate positives have been made from original negatives (on Eastman Color Negative Film) on a contact step-printer operating at the rate of 24 feet per minute, using a 1000-watt lamp at approximately 100 volts. Under these conditions, with the recommended Kodak Wratten Filter No. 2E and 4-mm Pittsburgh No. 2043X heat-absorbing filter, and with a 0.6 neutral density in the beam, the density timing diaphragm could be used at its central value. Intermediate negatives have been made from intermediate positives on the same equipment. In some specific cases, low-density Kodak Color Compensating Filters were required to achieve an optimum printing balance.

An Acme Optical Printer† has been used to prepare the second intermediate negative (at 1-to-1 magnification). With an $f/4.0$ lens opening, a 170° shutter angle, and a 500-watt lamp operating at 103 volts, a printer speed of 10 feet per minute was used. Again, the heat-absorber and a Wratten No. 2E Filter were required.

Processing of Eastman Color Intermediate Film, Type 5253

The processing steps for Eastman Color Intermediate Film, shown in Table I, are similar to those recommended for Eastman Color Negative Film, Type 5248,[1] and the film may be handled in the same equipment, with two important modifications.

Table I. Processing Steps for Eastman Color Intermediate Film, Types 5253 (35mm) and 7253 (16mm)

Step	Time at 70 F (21 C)
1. Prebath	10 sec
2. Spray rinse	10 to 20 sec
3. Color development	6 min* (±0.3 F)
4. Spray rinse	10 to 20 sec
5. First fixing bath	4 min
6. Water wash	4 min
7. Bleach	8 min
8. Water wash	4 min
9. Second fixing bath	4 min
10. Water wash	7 min
11. Stabilizing bath	1 min
12. Spray rinse	1 to 5 sec
13. Wetting agent	1 sec
14. Drying	15 to 20 min

* Exact time will depend on mechanical and other characteristics of processing machine.

In order to obtain fine grain and correct contrast, the time of color development of Eastman Color Intermediate Film is reduced to approximately one-half that used for Eastman Color Negative Film, Type 5248. Since individual processing machines differ, the exact time of development in a given machine should be determined by experiment.

The second modification involves a change in processing chemicals; a ferricyanide bleach formula (Kodak SR-9), as given in Table II, is required in place of the dichromate bleach formula recommended at present for Eastman Color Negative Film, Type 5248. The gelatin-tanning action of a dichromate bleach causes physical distortion in a dried color image, and it has been observed that objectionable edge effects are produced in the intermediate negative when the dichromate bleach is used in processing both the intermediate positive and the intermediate negative. These edge effects are significantly minimized when the non-tanning ferricyanide bleach is used.

Three precautions should be noted concerning the use of a ferricyanide bleach. First, the Eastman Color Films previously introduced are not designed for processing with this new ferricyanide bleach and, therefore, this bleach is not recommended for these products. Second, the corrosion problem with various steels and alloys is different from that encountered with the dichromate bleach, and, therefore, the bleach tanks and piping should be checked for use with the ferricyanide bleach. Third, the Intermediate Film processed with a ferricyanide bleach acquires a smooth surface with little relief image. Under certain contact-printing conditions involving a smooth surface in both negative and raw stock, and close contact between films, Newton's rings may form between the two films in the printer gate, and an ob-

* Manufactured by Pittsburgh Plate Glass Co., Pittsburgh, Pa.
† Manufactured by Producers Service Co., Burbank, Calif.

Table II. Kodak Special Bleach SR-9

(For use with Eastman Color Intermediate Film, Types 5253 and 7253)

	Avoirdupois-U.S. Liquid		Metric
Water, about 70 F (21 C)	96 gal	96 fl oz	800 ml
Kodak Potassium Ferricyanide . . .	50 lb	6¾ oz	50.0 grams
Kodak Potassium Bromide	20 lb	2 oz 290 grains	20.0 grams
or Sodium Bromide	17 lb	2¼ oz	17.0 grams
Water to make	120 gal	1 gal	1.0 liter

Adjust pH to 6.5 to 7.0 using 10% sodium hydroxide solution.
Dissolve chemicals in the order given.
Note: Because of the corrosive nature of this bleach solution, it is recommended that processing tanks and auxiliary equipment be lined with or be made of hard rubber, polyvinylchloride, or other inert material. Under emergency conditions, where stainless steel AISI 316 tanks must be used for a few hours, some protection against corrosion is afforded by the addition to Kodak SR-9 of 30 grams/liter or 4 oz/gal of sodium nitrate. After such use, the tank should be flushed thoroughly with water before using again.

jectionable print-through image may result.

Prevention of this Newton's-ring image can be accomplished by producing a rough surface on either the processed film or the raw stock being printed; this eliminates the intimate contact which produces Newton's rings. One successful method involves the spray application of an aqueous suspension of small particles to the processed Color Intermediate Film. American Type Founders Company Non-Offset Mix No. 109* applied as a fine mist by means of an airbrush, dries to provide a roughened surface to the Intermediate Film. One application has provided anti-Newton-ring protection for more than 100 passes through a contact printer.

Although the particles produced by this technique are small enough so that no image of them is printed in conventional contact printers, an objectionable print-through pattern of the particles may result from specular, optical printing operations. A simple water wash removes the particles from the film surfaces, in those cases where it is necessary to print a film optically after it has been sprayed with the Non-Offset Mix.

Experience with this technique for preventing formation of Newton's rings is quite limited in motion-picture production. Work is still in progress to determine such factors as optical effects of the particles under contact-printing conditions involving very specular optical systems, chemical effects of the spray on image stability, and other possible results of the introduction of a new material to film surfaces.

Process Control

Control of processing Eastman Color Intermediate Film, Type 5253, is more critical than that required for Eastman Color Internegative Film, Type 5245. With the separation positive–color internegative system (using Types 5235 and 5245 Films), some compensation for an off-standard internegative process can be made in the preparation of the separation positives. No such compensation is possible in the preparation of intermediate color negatives on Type 5253 Film; the process must be on-standard specifically for Color Intermediate Film, Type 5253.

It is recommended that the camera negative process, at the approximately 50% reduction in development time, be monitored with sensitometric exposures on the Type 5253 Film in use. The assumption that a process on-standard for Eastman Color Negative Film, Type 5248, will also be on-standard for Eastman Color Intermediate Film, Type 5253, at reduced development time, may not hold for all types of processing equipment.

Practical Applications of Eastman Color Intermediate Film, Type 5253

Eastman Color Intermediate Film is designed primarily for the production of intermediate positives and intermediate negatives for use as full-length printing masters. These printing masters may match the camera negative for size, as in the case of making a 35mm master from a 35mm original; in this case, a straightforward contact or a 1-to-1 optical printing operation at the intermediate positive and negative stages is required.

An especially attractive use for this single color-film, intermediate system is in the production of full-length color duplicate negatives reduced in size from the original camera color negative and which will permit release prints to be made in contact printers. A 35mm color duplicate negative from a "large-size" original, and a 16mm color duplicate negative from a 35mm or larger original color negative are examples of this use. In this application, the reduction printing operation should be postponed to the latest practical stage in order to obtain optimum picture sharpness.[4] In the production of a 16mm color duplicate negative from a 35mm original color negative, a 35mm intermediate positive is made on Color Intermediate Film, Type 5253, using a contact or a 1-to-1 optical printer. This positive is then reduced by optical printing to make a 16mm color duplicate negative, using Color Intermediate Film, Type 7253.

Unlike the silver images of separation positives, the dye images in Intermediate Film have about the same effective contrast for optical and contact-printing conditions. Hence, the same intermediate positive may be used for either optical or contact-printing to the next stage.

Some simplification in the production of still and traveling mattes may result from the use of this film, since the number of passes in the process camera or printer can be reduced in number. Uses in process photography involving artwork and other direct photography may be found for Intermediate Film, Type 5253, since the sensitization-to-image color relationship is that of conventional camera films. In the introduction of scene-to-scene transitions, the matched contrasts of the Intermediate Film should facilitate making uniform color fades and lap dissolves.

Intermediate Film, Type 5253, may be used in place of Eastman Color Internegative Film, Type 5245, in the preparation of an intermediate negative from three black-and-white separation positives. However, because of differences between the two color films it is probable that separation positives made specifically for use with Internegative Film, Type 5245, will not be satisfactory for printing onto the new Intermediate Film. The contrasts of Internegative Film, Type 5245, and Intermediate Film, Type 5253, are not exactly the same, but this factor alone might not call for new positives in all instances. The different emulsion-sensitization to image-color relationship in the two films requires that a given separation positive be printed with a different colored light in the two cases. For example, the blue-separation positive (yellow printer) is printed onto Internegative Film, Type 5245, with *red* light to produce an image in yellow dye; this same positive would be printed onto Intermediate Film, Type 5253, with *blue* light to produce a yellow dye image. The character of the silver image in Pan Separation Films, Type 5216 and Type 5235, is such that the contrast of a separation positive to red light may be as much as 15% lower than its contrast to blue light. Therefore, when Eastman Color Intermediate Film, Type 5253, is used in place of Eastman Color Internegative Film, Type 5245, it is probable that a set of separation positives will have to be made specifically for that use.

It should be noted that, with a multiple-film system involving only color films, no protection is provided against loss of the color original or the intermediate film due to possible changes of the image

*Manufactured by American Type Founders Co., Elizabeth B, N.J.

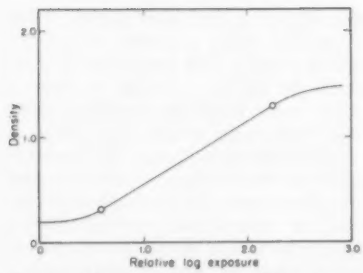

Fig. 5. Characteristic curve of red record of Eastman Color Negative Film, Type 5248. Circles indicate density range of important subject matter.

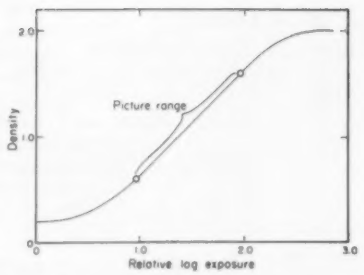

Fig. 6. Characteristic curve of red record of Eastman Color Intermediate Film, Type 5253. Circles indicate density range of subject matter for optimum tone reproduction.

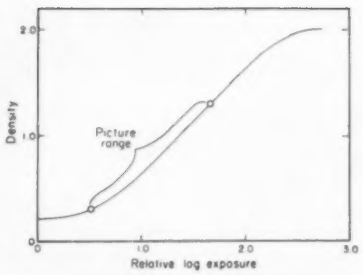

Fig. 7. Characteristic curve of red record of Eastman Color Intermediate Film, Type 5253. Circles indicate density range of subject matter when a "thin," intermediate negative is made.

dyes. Although the dye-stability of processed Intermediate Film is comparable to that of Eastman Color Negative Film and Eastman Color Internegative Film, silver-image separation positives or negatives should be made if such protection is desired.

Sensitometry

An important factor affecting tone reproduction in color duplicating systems must be considered here. In Fig. 5, the characteristic curve of one record of a camera negative original is shown. A plot of density-vs.-log exposure produces a short, curved portion in the lower densities, a long straight-line portion, and a curved portion at high densities. When exposure recommendations for the camera negative are followed, the important picture information falls on the straight-line portion of the curve, as indicated by the circles, permitting the various brightnesses of the original scene to be reproduced in the negative in an undistorted relationship.

To produce an intermediate negative of high quality, a linear relationship between the densities in the original negative and the densities in the intermediate negative must be maintained to ensure a minimum of distortion in reproducing the curve shape of the original negative. The Intermediate Film is designed to have a straight-line portion in its characteristic curve adequate to accommodate the density range of the picture material as recorded in the original camera negative. By proper use of this straight-line portion, a minimum of distortion may be obtained. However, as with all other color films, the straight-line portion of the Intermediate-Film characteristic curve does not begin at an effective density of zero; there is a low-gradient portion of the curve in the low-density region. Therefore, the exposure given the Intermediate Film in the positive and negative stages must be sufficient to place the picture density range of the original camera negative on the straight-line portion of the Intermediate-Film characteristic curve. This condition is shown in Fig. 6, where density-vs.-log exposure for one record of the Intermediate Film is drawn, and the picture-density range is given by the circles.

Original camera negatives often have important information in the lowest possible densities, including the curved "toe" portion of the characteristic curve, and it will be evident that an intermediate negative, prepared as described, may be denser than the original camera negative.

A thin, duplicate negative will be produced by the utilization of the curved lower portion of the Intermediate-Film characteristic curve, as shown in Fig. 7, where the picture-density range is again indicated by circles. The degree of distortion of the tone scale which is thus introduced will be more or less noticeable in various scenes, depending on how much of the scene-brightness range is reproduced on the nonlinear portion of the characteristic curve. A high-key scene, for example, may show no distortion, since its lightness and limited brightness range cause it to be reproduced entirely on the linear portion of the curve. On the other hand, a night or a low-key scene will, for the most part, occupy the nonlinear lower part of the intermediate negative curve, and poor tone-reproduction characteristics will be evident in the final print.

In some production situations, a laboratory may feel that it is necessary to depart from optimum tone reproduction. For example, a thin, intermediate negative may be prepared to be intercut with a thin, camera negative, in order to minimize color and intensity timing changes, or a thin, printing master may be prepared for use on a printer having insufficient light intensity. It should be emphasized, however, that the characteristics of the new Intermediate Film are such that this procedure will invariably lead to a loss in quality of the final print, just as it does in the case of Internegative Film, Type 5245. Thin, intermediate negatives should be avoided wherever possible.

If such a departure from the use of the straight-line portion of the Intermediate Film is resorted to, the departure should not be introduced in the preparation of the intermediate positive. Distortion at both the intermediate-positive and the intermediate-negative stages, in effect, compounds the quality loss.

The foregoing discussion points to the need for a method for determining the sensitometric characteristics of the Intermediate Film and the placement of picture information on this film. A sensitometer capable of exposing Eastman Color Intermediate Film at exposure times approximating those encountered in actual printing operations is recommended. Sensitometers used for exposing Internegative Film, Type 5245, or Print Film, Type 5382, have been found adequate for this use. A single, color-balanced, white-light exposure is required. If a sensitometer is not available, sensitometric exposures can be made on a scene-tester or a printer equipped with a full-frame, silver-image step tablet.

The characteristic curve shown in Fig. 2, for example, resulted from an exposure made on an intensity-scale sensitometer using 2850 K illumination, a 4-mm thickness of Pittsburgh No. 2043X heat-absorbing glass, a Corning Glass Filter No. 3307* simulating the minimum density of Eastman Color Negative Film, a Wratten Filter No. 2E, and an exposure time of 1/25 sec.

The Status K Filters recommended for use with Eastman Color Negative Film, Type 5248,[1] are suitable for the densitometry of Eastman Color Intermediate Film, Type 5253. The density values obtained will not be true printing densities, owing to differences between film spectral sensitivity and the combination of filter transmission and photocell spectral sensitivity. Because of this, the contrast of the Intermediate Film as measured on a densitometer may depart from unity. True printing densities may be determined empirically by photographic means.

Besides providing a basis for deter-

* Supplied by Eastman Kodak Co. for use with the Eastman Sensitometer, Model 15.

mining correct exposure conditions for the intermediate film, the characteristic curve, when derived from reproducible exposures, provides a convenient monitor of film and process variations which aid in process control.[5]

The raw-stock and latent-image keeping characteristics of Eastman Color Intermediate Film, Type 5253, are quite similar to those described[1] for Eastman Color Internegative Film, Type 5245, and the same procedures are recommended for the handling and storage of both types of film.

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Samuel B. Grimson's Investigations of the Line-Screen Method of Color Separation and Reproduction

By SEYMOUR ROSIN

The use of a coarse diffraction grating on a line screen in conjunction with a banded filter in the lens aperture presents a unique optical device with one definite "focal" position. The resultant vivid color bands at the film plane may be applied to color reproduction in photography or television.

ALL ADDITIVE color methods are achieved through the mixture of three so-called primary colors. This mixture may be made on a time basis or a space basis and depends essentially on the lack of resolution of the visual apparatus. On a time basis, this lack of resolution may be otherwise described as "persistence of vision" or "flicker discrimination." On a space basis, this mixture is achieved by spacing the primary colors so close together in comparison with the viewing distance that the eye cannot discriminate the separate colors and sees them mixed in additive form.

The method of this article is based on crossing the image lengthwise with strips of primary colors so closely spaced that the eye will be unable to discriminate them.

One of the methods most familiar to motion-picture engineers is the Keller-Dorian process,[1] shown in Fig. 1. The camera lens at L forms the image at the film plane F. Placed close to the lens is a filter arrangement consisting of three transmission bands of the primary colors red, green and blue, as in Fig. 2.

Since it is placed close to the lens, its size and position are only slightly altered by transmission through it. Small embossed cylindrical lenses, integral with the film, form tiny images of the colored bands on the film plane. The exposure in each of these bands depends upon how much of each color exists in the object. Upon development and printing, the film is projected through a lens equipped with the equivalent banded filters.

One serious disadvantage with this process is the need for special expensive film to keep the color band images integral with the embossed cylindrical lenses. It seemed obvious that a method producing color bands of this type on ordinary black-and-white film would be extremely desirable, and it seemed necessary only to search for a method by which the optical means for forming the color band images are divorced from the film.

Such a method has been proposed for many years and involves the use of a slit as the image-forming device in a means analogous to that of the pinhole camera (Fig. 3).

An object, O, is imaged at I by means of a small opening, P. If the opening is large, the image is blurred. If it is small, the light intensity is reduced and blurring occurs because of diffraction out of the central band. An optimum size exists which is principally a function of the distance between P and I. There is no precise focal plane at I; the image is in focus anywhere behind the opening, P.

If, now, the object, O, is a banded filter comprised of strips of red, green and blue (Fig. 4) and if the opening, P, is a

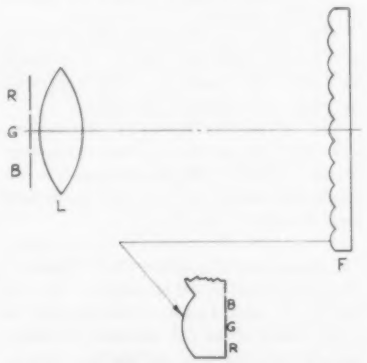

Fig. 1. Optical arrangement, Keller-Dorian Process.

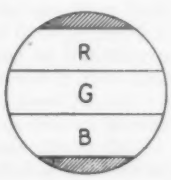

Fig. 2. Tri-banded filter, Keller-Dorian Process.

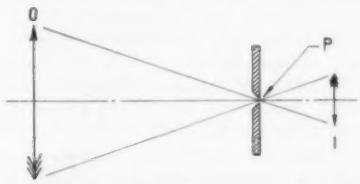

Fig. 3. Optical arrangement, pinhole camera.

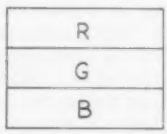

Fig. 4. Banded filter, pinhole camera.

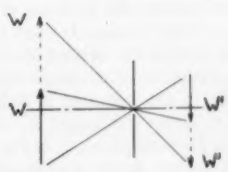

Fig. 5. Illustration of zero mapping distortion, pinhole camera.

A contribution submitted on October 1, 1956, by Seymour Rosin, Grimson Color Inc., 381 Fourth Ave., New York 16. This article is compiled from the notes and diaries of Samuel B. Grimson from the years 1938 through 1943; and is herewith offered posthumously so that the results of his research may be available to the scientific and technical community.

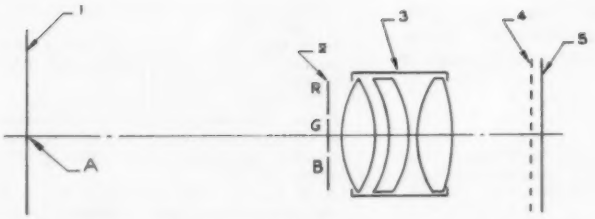

Fig. 6. Optical arrangement, simplified coarse-screen color process.

Fig. 7. Band imaging system of Fig. 6.

slit, the image, I, will be a band of colors corresponding to O. It is interesting to note that, unlike the pinhole camera, there is no point-to-point correspondence between object and image as in the case of the pinhole camera; rays of light originating anywhere in the band, R, will be spread out over the entire red band in the image.

Another extremely important feature of the pinhole camera is the fact that the mapping distortion is exactly zero (Fig. 5). If a band of width, w, is imaged on the screen, its image has the width, w′, depending on the proportional distance from the pinhole. If w is slid in the plane to a position considerably off axis as shown, the image will move correspondingly off-axis, but the width of w′ will be unaltered. If the object consists of a series of bands all of exactly the same width, the image will be a series of bands all of equal width, regardless of the angular subtense at the pinhole.

A number of investigators have done work with this method, among them Walter Gieseke (1899),[2] Frederic E. Ives (1900)[3] and, notably, Georges-Andre Raguin (1923).[4] A recapitulation of the method follows (Fig. 6).

In the figure, 1 represents the colored object to be reproduced; 2 represents a 3-banded filter comprised of equal widths of red, green and blue bands; 3 represents the camera lens; 4 represents a line screen comprised of alternate transparent and opaque lines; and 5 is the image which is to be represented in true colors. Each transparent line in the screen, 4, will act as the slit in Fig. 3.

There are really two image-forming systems involved. The first consists of 1, 3 and 5, which is merely the fact that the lens forms an image of the object in the focal plane. The second consists of 2, 4 and 5, and together form the banded system, described previously, but more detailed as follows. (Parenthetically, since the banded filter, 2, is placed practically in contact with the lens, 3, it is unaltered in size and position as viewed from the focal plane. It may also be placed immediately behind the lens, or even in the plane of the diaphragm.)

In Fig. 7, the opening, a, in the line screen, 4, forms the image B_a G_a R_a of Fig. 8 on the focal plane, 5, of Fig. 6.

While in the figure the image interval R_a, G_a and B_a seems to occupy a large distance on the image screen, in practice the screen, 4, is so fine and the interval, S, so short, that the three bands occupy a space no larger than the normal "blur circle" in the gross-image-forming system comprised of 1, 3 and 5. Since the screen consists of a large number of evenly spaced slits, the result of illuminating the banded filter, 2, with white light is the formation of a repeating series of colored bands (B_a G_a R_a, B_b G_b R_b, . . .) at a distance, S, behind the screen.

To illustrate the operation of the process, let us consider a red object at 1 of Fig. 6. Red rays strike the banded filter, 2, and only the red element, R, can transmit these rays to the lens. Each opening in the line screen (a, b, c, d, . . .) will give rise to a colored band (R_a, R_b, R_c, R_d, . . .) in the image plane, 5. The gross image of the red object will therefore consist of a series of red lines separated by opaque lines, D, as shown in Fig. 9.

The opaque lines, D, correspond to the bands G_a B_a, G_b B_b, etc., which cannot form for lack of green and blue light. A blue object would be represented in the image plane by a series of blue lines (B_a, B_b, B_c, . . .), separated by opaque lines corresponding to R_a G_a, R_b B_b, etc. Object colors which can reflect light of all visible wavelengths will form bands of all three colors, the intensity of which varies in proportion to the color composition of the original.

The colored lines in the focal plane, 5, can be recorded on film or any other light-sensitive medium, and represent the color separation information.

Let us discuss now the separation, S, of the line screen, 4, from the image plane, 5 (Fig. 7). If this separation is too small, the bands on the image plane will look as follows (Fig. 10):

The interval between the center of the "a" bands and the center of "b" bands is of course equal to the spacing on the line screen, 4, and equal dimensionally to 1/N, where N is the number of transparent lines per inch on the line screen. As the distance, S, is increased, the band systems a and b both grow on the focal plane at the expense of the dark interval in between, until finally the latter disappears and the band systems just touch each other. If S is increased beyond this, the colored bands of one system overlap those of the next and confusion results.

While ideally the bands are sharp for all values of S, one might say that they

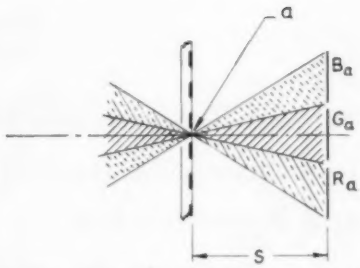

Fig. 8. Enlarged focal-plane view of Fig. 7.

are in "focus" when this contiguous condition is satisfied. Let us take a case in point. Suppose the lens, 3 (Fig. 6), is one of aperture $f/3$, and suppose the line screen is engraved at 500 per in. Then the red, green and blue bands together occupy at the contiguous position exactly 0.002 in., and the distance S is $0.002 \times 3 = 0.006$ in.

What do we have at this point? We have at the focal plane an image in black-and-white in which all the color information is stored. In color photography, the colors can be reproduced by printing and projecting back through the line screen and banded filter, or color separations can be made by printing in contact with line screens. In television the colored bands can be scanned separately and combined in a number of familiar ways.

This system has a number of deficiencies which can be overcome in a novel fashion. These deficiencies may be listed as follows:

1. The bands are not sharp. As stated earlier, the diffraction theory gives an optimum size opening in the line screen which gives the sharpest bands. Here, especially, where the opening is of the same order as that of each band, it is important to bring diffraction effects to the aid of the image and not to its detriment. While the exact diffraction theory analysis is exceedingly complex, an idealized simple calculation shows that the best results could be expected if the relative aperture of the three bands could be reduced to $f/10$ or thereabouts, thus increasing the distance, S.

2. The distance, S, is mechanically too small and critical.

3. Color fringing for out-of-focus objects.

This defect, also present in the Keller-Dorian method, is due to the fact that the

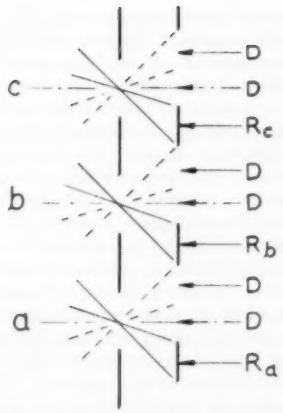

Fig. 9. Red band-imaging process through adjacent slits.

red rays are restricted to a portion of the camera lens near one side, the green to a portion in the middle and the blue to a portion on the other side. The center of gravity of the red and that of the blue are shifted with respect to one another on the lens surface. If the object is in exact focus on the focal plane, the effect is negligible, but background or other objects producing a blur circle of appreciable extent on the focal plane will have this blur colored blue on one side and red on the other.

Fig. 11. Eight-banded filter, line-screen process.

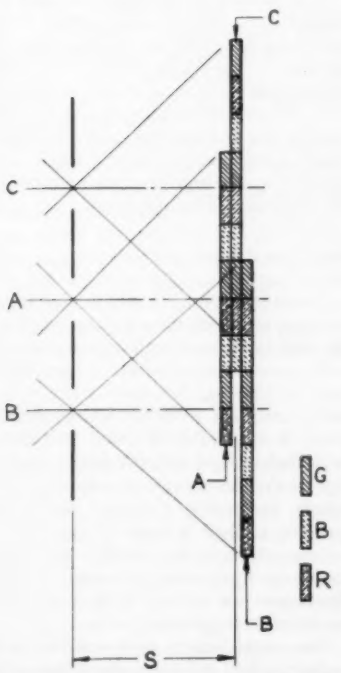

Fig. 12. Overlapping color bands in focus, Grimson Line-Screen Process.

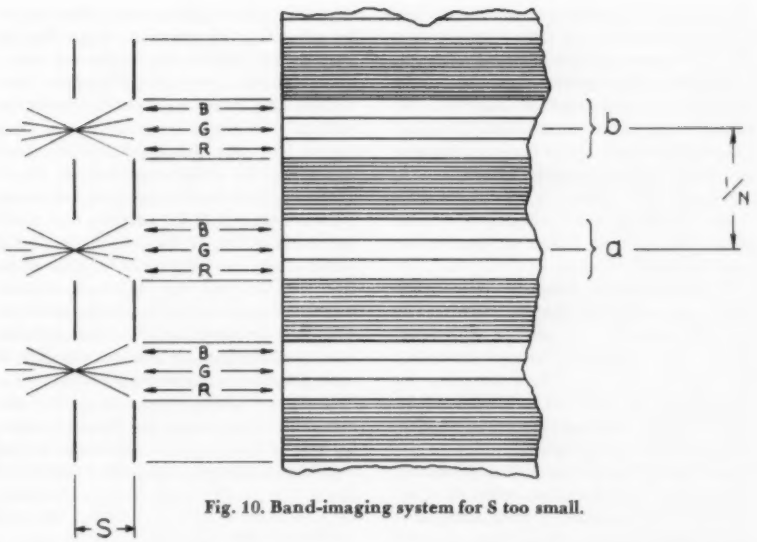

Fig. 10. Band-imaging system for S too small.

These deficiencies can be reduced by the following method. The number of bands in the filter are increased. For example, suppose they are increased to eight as in Fig. 11. The number eight is chosen as a general figure and has no significance in itself.

Each opening now produces eight bands of color in the focal plane. However, each band of color receives light not from just one opening in the line screen, but from three for the red and green and two for the blue. Inasmuch as we must maintain the contiguous relationship of R,G,B, as explained above, we will have overlapping of the colors as shown in Fig. 12; however, the relationship of the three bands of fundamental color for each opening in the line screen is maintained.

Note that the deficiencies enumerated earlier have been either sharply reduced or eliminated. The center of gravity of the various colors on the face of the lens coincides exactly with the lens center in the case of the blue, and very nearly with the lens center in the case of the red and the green. Using the example of the $f/3$ lens cited earlier, any three contiguous R,G,B bands on the filter subtend an aperture of only $f/8$ at the focal plane and the distance, S, is increased from the earlier 0.006 in. to 0.016 in. This greatly helps the sharpness of the individual bands and reduces the proximity of the line screen to the focal plane.

Experimentally, these results are borne out quite vividly. One may easily set up the three-banded and the multibanded systems and examine them with a medium power (say 50×) microscope trained on the focal plane (Fig. 13). The distance, S, is varied by adjustment with the fine-motion focusing rack of the microscope.

The microscope is racked forward until the line screen is in focus, and then slowly racked back. In the three-banded case, the colors are pale and diluted.

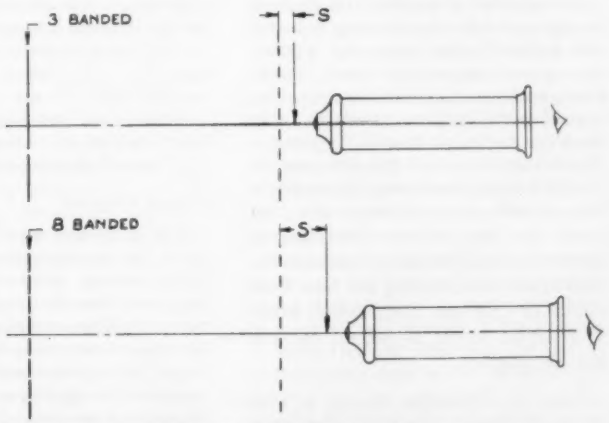

Fig. 13. Experimental setup for viewing color bands.

As the microscope is moved, the bands increase in width until they touch, but do not appear clearly defined. In the case of the eight-banded filter, the bands appear hopelessly jumbled together until when the correct value of S is approached, order is made out of chaos and the bands appear sharply defined and in vivid, saturated color.

In adapting the method to color photography, the following procedure was followed.

First, a standard Mitchell NC camera was employed, with the aperture plate modified to hold the grating (ruled on glass) at the required distance from the film during exposure. The roller plate as used in the Mitchell was replaced by an intermittent noiseless pressure device giving elastic but positive contact on all four sides of the picture area. With the employment of an eight-banded filter in contact with the camera lens, color records of many and varied subjects were exposed over a period of years. Prints were made from the reversed negative by contact exposure.

Theoretically, it should be possible to obtain projected pictures in color simply by reversing the process. A grating in front of the print in the projector and a banded filter over the projection lens would serve to separate the colors on the screen. This simple procedure was frustrated by the phenomenon of film shrinkage. It is obvious that a single grating of definite line spacing could not be made to match the varying line spacings on the film if the shrinkage of the latter could not be precisely controlled. For this reason, an elaborate optical printer was devised, the details of which will not be discussed in this article. However, this printer made it possible to incorporate an optical device whose position in the optical train could be adjusted to compensate for the shrinkage. In this device, satisfactory color prints could be obtained on regular subtractive stock.

Author's Note

The line-screen method described above was the subject of several years' research and development by Mr. Grimson in the late thirties and early forties. No one of us who saw the beautiful color rendition achieved by him on ordinary black-and-white film could help but wonder why his method was not more fully exploited commercially. Several vexing problems associated with the photographic method remained and these were never solved to Mr. Grimson's satisfaction. Among these were the questions of film shrinkage, processing, registration and foreign particles in the confined space between the line screen and the film. None of these problems appears to be of consequence in applying the method to television and investigation is now proceeding to this end.

The writer wishes to express his appreciation to Carl Weiss for his invaluable aid in assembling this material from Mr. Grimson's notes.

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Techniques of Television Lighting

By DAVID THAYER

Practical TV studio-lighting procedures are outlined with emphasis on monochromatic TV. Solutions are suggested for some of the lighting problems arising from the technical limitations of the TV system, the key-light system of TV lighting is contrasted with the base-light system, and considerations in the selection and placement of instruments are presented. Practical methods of controlling light so that it may contribute to the aesthetic realization of the show are touched upon.

It is difficult if not impossible to set down rules to dictate a "method" for effective lighting, and it is the author's belief that it is theoretically wrong to do so. He has been convinced, however, by several years of working with students of stage and television lighting that it is very helpful if there is available a group of concrete suggestions about procedures, equipment and its use, and solutions of special problems which may help them get started. It is with the thought that a compilation of this sort may be helpful to many practicing lighting directors as well as to beginners that this article has been written. The material has been drawn primarily from observations made while visiting the New York studios of CBS and NBC, and so serves as a partial record of current network lighting practice.

A contribution submitted on February 20, 1957, by David Thayer, Television Center, State University of Iowa, Iowa City, Iowa.

Although these notes apply primarily to monochromatic television, lighting for color is very similar, the chief differences being in both relative and absolute light intensities and in concern with color temperature. Greater intensity means the use of additional instruments and in many cases lamps of larger wattage. Lamps designed to give color temperature of roughly 3000 K are used. Otherwise techniques are very similar, and the majority of the discussion will apply to color as well as black-and-white.[1]

Picture Contrast

The literature usually gives a ratio of 20:1 as the permissible contrast range of the average television system. Lighting must limit the brightness range between highlight and shadow to this ratio if detail is to be seen at the extremes of the range, but it is impossible to set up absolute rules for lighting on the basis of this limitation since many factors other than lighting enter into the contrast range of a scene, especially set reflectivity contrasts, hair types and skin types.

It is usual to quote figures for the allowable ratio of key to base, but in practice these can only be rough guides. A base-light level which is 60% of the key is common (or a ratio of key to base of 5:3). When contrasts between actor and scenery are low (so that under flat light only a portion of the range is used), it is possible to use high-contrast light up to the contrast limit of the scene.

Light Level

There is nothing in the limitation of contrast which dictates average or overall light levels, and although the literature usually recommends a base-light level of 100 ft-c, this level is not necessarily desirable from an artistic standpoint. It is essential, of course, that there be sufficient light actually falling on the face of the image-orthicon tube for technically acceptable pictures. Since this quantity of light is fixed by the characteristics of the particular tube and of the associated equipment, the variable which determines the amount of light incident on the set is the desired *f*-stop.

Numerous factors, both aesthetic and technical, will influence the selection of the *f*-stop to be used. When it is desired to have actors separated in depth or

actors and background in about equally sharp focus, depth of field must be increased by stopping down most lenses, and relatively high light levels must be used. Conversely, if the actor is to be etched in sharp focus against a background which is slightly out of focus, the lenses must be opened up and light levels reduced. Not only do directors often consider essential the emphasis placed on the actor by a reduced depth of field, but it is also claimed that light at the lower levels is more flattering to the actor.[2] Occasionally, when backgrounds are not in sharp focus, they need not be executed in as meticulous detail as is required when they are to be seen clearly. One of the chief problems encountered when using large lens openings is the difficulty of maintaining focus as actors and cameras move about the set, and many studios find that it is safest to use a smaller lens opening with the attendant increased depth of field.

It may be seen that the problem of light level is not simple, and it may be further complicated through misunderstanding. For example, when a video-control man says he needs more light, he usually does not mean that greater intensity is needed for acceptable pictures, but rather that there should be a better balance between key and base or between faces and background.[3]

Established lighting directors generally base overall levels on experience rather than on a conscious decision to light for a particular *f*-stop. Light meters are seldom required by experienced lighting men except when working with high intensities (as in color) where the eye is less sensitive to brightness variations, or when working with unfamiliar equipment or in an unfamiliar situation. The camera is considered to be the best and final judge of lighting adequacy.

Broadly speaking, NBC uses higher light levels and smaller lens openings than does CBS, although levels may be similar on particular shows. At NBC, *f*-stops range between *f*/8 and *f*/16 with typical light levels between a base of 64 ft-c and a key of 100 to 150 ft-c. CBS uses *f*-stops between *f*/3.8 and *f*/8, with *f*/5.6 recommended.[3] Base levels may be as low as 30 ft-c with nothing on the set over 90 ft-c.

Principal Light Sources for Picture Production

The literature has stressed base light as a light peculiar to television and as the principal source of light by which the television camera produces pictures — in contrast to photography in which the key light serves this function. The use of base light as the principal light (and often the only light) for camera operation is common in studios where time and personnel are limited, and indeed it is probable that this type of lighting is the only method practical for many small stations. Lighting directors with the networks have, however, abandoned this approach almost entirely.

In former practice, base light of adequate intensity was established and key light superimposed. In the system currently employed by networks, the key-light level is first established for acceptable noise-free pictures. Then other modeling lights and finally base light are added to the key in sufficient amounts to make shadow areas transparent and to give artistically pleasing contrasts. The base light then becomes more nearly analogous to fill light. It is important to remember that, if it is to be used as the principal light for picture taking, the key must have sufficient intensity and coverage to light the subject adequately.

Although the difference of concepts is primarily one of emphasis rather than method, since either system may lead to equally effective lighting, certain variations in technique may be noted. When illumination for picture production is provided by the key light, it is possible to vary the base-light level over a wide range with corresponding changes in picture contrasts. In shifting from high-key to low-key lighting, base-light intensity is reduced to provide greater contrast of key to base rather than the key light being increased. With base light as the reference, it is common to find that a properly lighted night scene has more light on it than does a brightly lighted interior since all effects must be obtained by building on top of the base light. This paradox need not occur in studios which use the key light as a reference.

Lighting Equipment

The most useful lighting instruments are the 18-in. scoop, single broad, clip-ons using R-40 lamps, 750's (baby kegs), aces (1000-w Fresnel spotlights), deuces, and 5000's (rarely used in black-and-white, but common in color). Ellipsoidal spotlights and other specialized equipment may be used when needed. Fresnel spotlights are generally used with barndoors and occasionally with other accessories to control the distribution of light.

Since the floor must be kept clear for movement of cameras and other equipment, most instruments are mounted from above. There are three basic systems of mounting equipment which may be used singly or in combination to give a method having advantages for any particular studio. Instruments may be mounted directly on battens which can be lowered to the floor, or they may be mounted on slider rods from a fixed grid by men walking on catwalks, or on "pantographs" or slider rods clamped to a fixed grid by men working from ladders. Small instruments are often mounted directly on the scenery using scenery clamps, clip-ons, or alligator clamps. When necessary, instruments may be mounted on castered stands or placed directly on the floor.

It is desirable whenever possible to connect all instruments to dimmers for balancing intensities during setup, rehearsal and performance. Some lighting directors start lighting with their dimmers down one point in ten so that they may adjust up as well as down, while others try to avoid dimming because they feel that a scene loses "sparkle" as a result of dimming. Instruments are ganged on dimmers at the board so that they may operate as a unit, or so that dimmers may be conserved.

Types of Light

Light may be divided into types on the basis of function.[4] The principal types are key light, back light, set light and base light. The first three of these are termed "form-revealing" or "modeling" light. Of these, key light is the most important. In addition to its use as the principal light for camera operation, it provides modeling or a sense of the third dimension by creating highlights and shadows on actors and sets. Further, it is possible by its placement and control to convey locale, time of day, mood and other information about the scene. Because it is shadow-producing, one of the major problems in the use of key light is shadows of the microphone and boom produced by key light in the field of the camera. It should be pointed out that unwanted shadows are seldom eliminated from the set, but rather are hidden from the camera by skilled instrument placement and by the cooperation of the boom operator.

Fresnel spotlights are generally used for key lights, the wattage and size used depending on throw and spread needed. Spotlights are used at nearly full flood for maximum efficiency. If it is necessary to spot down an instrument to gain sufficient intensity, the chances are that the instrument is of insufficient size. Very few diffusers or scrims are used on the key lights, since a hard light is generally desired. Two-way or four-way barndoors are used with most key lights.

While key-light angles are ideally chosen for desired pictorial effect, mounting positions will be influenced by camera shots, boom positions and motivating sources in the scene design. Since these factors are highly variable, it is difficult to generalize about key-light placement, but a few statements of common practice may be made.

It is important when lighting dramatic shows (and to a lesser extent nondramatic shows) that there be an apparent source for the key, and, indeed, in the opinion of many lighting directors, the use of nonmotivated light is one of the worst sins that can be committed. It is quite possible to cheat the actual key away from the motivation by a rather wide

angle when necessary to light a subject properly for particular camera shots and to help hide microphone shadows. If this angle becomes too great, however, it is probable that a new motivation will be found. When motivations are not visible in a scene design, it is usual to assume a motivation such as an overhead light or windows in the fourth wall.

Key lights are placed at angles approximating that of the light from the motivating source. When there is a choice of angles, it is often advantageous to place the key at the side or back of the set with the beam directed downstage, thus throwing shadows toward the front of the set and out of camera range. This placement is often used when lighting two persons who face one another. By using a motivating source at the back of the scene (or assuming one), key lights may be crossed into the faces of both persons from the side and back so that both faces are well lighted without danger of microphone shadows.

Instruments mounted at the sides or rear of the set must usually be above the walls, although on large sets key lights may sometimes be mounted within the set area. When the lights are mounted above the flats and are intended to cover a large portion of the set, they are commonly placed about 13 ft above the floor (on sets with 10-ft walls) and 1 to 3 ft behind the walls of the set.

When actors work near the walls of the set, it is well to mount the keys at steeper angles than would ordinarily be used so that light on the upper portions of the set can be restricted. In many instances when actors work near the walls of the set, it is possible to combine the set and key lights, and barndoors may be set accordingly. By making instruments do double duty, the number of shadows cast on the wall is minimized and a more realistic effect obtained. Key lights on the open side of the set are usually lower, between 7 and 9 ft, so that microphone shadows are thrown into the upper portions of the setting out of camera view and so that faces will be efficiently lighted. These instruments must be positioned carefully if shadows are to be hidden.

It is generally important that the eyes of the actors be seen clearly since they are the most expressive part of the actor's face. Key lights on actors sitting or looking down often must be mounted lower than when the actors are looking straight out. When faces are to be seen without shadow areas (but not lighted "flat"), key lights must be mounted very nearly at head height and from close to the camera position.

On the *Hit Parade*, where very little effect lighting is used on faces, key lights (usually deuces) are often mounted at head height on castered floor stands and brought in from very near the camera. As actors and cameras move about the floor, the keys are dollied, trucked or panned as needed to keep an approximately constant spacing between key and actor. Key-light angles may be used deliberately to affect an actor's appearance. For example, elevating the key will accentuate natural age lines and give a harder or more rugged appearance, while lowering the key below head height gives an unnatural or mysterious effect.

It is usual to use both top and bottom barndoors to restrict the key light so that it does not fall higher on the walls of the set than is necessary, and so that the lower portion of the beam does not spill into areas covered by other keys (causing hot spots), or onto the floor or props. Treated in this way, the key light consists of what might be thought of as wedges of light covering the plane occupied by the actors and desired adjacent areas, but with little spill into other portions of the set. By minimizing light on the upper walls and floor, attention is directed to the actors and away from the scenery.

The intensity of the key will decrease with the distance from the lighting instrument. In black-and-white television, dimmers may be used during the performance to maintain a constant key-light intensity on the action as it shifts up and down stage. When dimming is not practical, half-scrims may be used to act as selective dimmers. Placed in the lower portion of the spotlight beam, they permit the upper portion to punch back into a set with full intensity. As an actor approaches the instrument, he moves into the scrimmed portion of the beam, which is less intense. Thus, an even key intensity can be obtained on the actor without the use of dimmers. Half-scrims may also be used vertically to reduce hot spots due to overlap of spotlight beams.

Back light comes from behind the actor to create a bright outline around his head and shoulders to separate him from the background. In addition to its primary function as a modeling light, back light may be used for scenic effect; for example, the most practical method of indicating bright sunlight is to increase the intensity of the back lights to give the effect of the sun falling over the shoulders of the performer. Whenever possible, back lights should be motivated, but when no motivation can be found, it must be remembered that back light is not a natural light and intensities should be used which are as low as practical, consistent with adequate separation. In dramatic shows it is sometimes necessary or desirable to use cross back lights or kickers, rathers than true back lights, and back lights may occasionally be combined with key lights.

Back lights are Fresnel spotlights, usually 750-w, aces or deuces and (rarely) 5000-w for scenes supposed to be played in bright sunlight. Scrims are seldom used, but barndoors are necessary to restrict the light, especially from the camera lens. The instruments are normally mounted about 13 ft above the floor and somewhat behind the walls of the set. Angles are steep, often in the neighborhood of 75°. Steep angles are unfortunate but unavoidable when actors work close to the walls of the set. An angle approaching 45° is generally desirable, since it gives maximum separation without objectionable highlights on the head and shoulders, but it is seldom attainable.

Set light is intended to fall primarily on the set wall, although its use as a key light for actors working near walls has been mentioned. Since the effects of set light may be seen as a part of the background to most shots, it may be of major importance in giving the lighting its distinctive character, in creating mood and in indicating locale. In these respects, set light may be more important than the key light since the effect of light on the walls may be more easily discerned than is light on the actors only. A technique which has proved useful for shows using a permanent lighting setup, or where action cannot be determined in advance, uses set light to "key" the walls of the set and a relatively flat general light in the acting area.

Set light is seldom washed indiscriminately over the walls but rather the distribution is restricted in various ways. Although the placement and distribution of set light is dependent upon the particular show and the artistic abilities of the lighting director, the patterns of light are partially arbitrary, even when motivating sources are present in the scene. Generally, the upper portions of the set are kept relatively dark by barndooring down the set lights (and key lights falling on the walls) until they just clear the actors' heads. Besides deemphasizing the upper portions of the picture, setting barndoors in this way minimizes microphone shadows.

It is effective pictorially to set the barndoors so that the portion of the wall behind the actor's head is darker than the lower portions. The head then stands out in contrast to the dark upper wall while clothing contrasts well with the brighter lower portion. Back light will be more efficient against a dark background and intensities may often be reduced accordingly.

Set light may be further restricted or broken up by using cookies or silhouettes of wood, metal, cardboard or plastic or real objects such as tree branches in front of a Fresnel spotlight. Ellipsoidal spotlights equipped to take "gobo" slides may be used when sharper patterns are desired. These slides may be cut from aluminum foil, shim brass, screen or expanded metal, or metal and glass slides may be purchased. Projections from ellipsoidal spotlights will usually be most effective if the instruments are slightly out of focus, since they look less like projections and so call less attention to themselves.

The light and shadow patterns may be either realistic or abstract, but in any case they must be consistent with the mood and style of the scene and should represent the lighting director's best contribution to the overall effectiveness of the scene. A use of set light which is often overrated and misused is the washing of microphone shadows from walls. While occasionally effective when carefully used, the method is generally slipshod and only partially efficient since it usually results in additional shadows and in too much light on the walls relative to faces. When possible, it is usually better to relight a set than to try to wash out shadows.

Unlike the modeling lights, base light produces a minimum of modeling. It is a virtually shadowless light uniformly distributed over the set and playing area to provide overall intensity and to reduce contrasts caused by the modeling lights. It serves the functions of a photographer's fill or front light but is somewhat more general. Scoops, cone lights and strip lights are used extensively for base light, with fluorescent banks, broads and spotlights used occasionally.

Spun-glass diffusers are often used on the scoops to further soften the base light and increase diffused floor reflections which, to a large extent, provide fill light to soften shadows under chins and in eye sockets. Since a typical diffuser cuts the light output by 40%, diffusers are seldom used in color work.

Even though the key light is primary, the base light is often rigged first because it provides work light for set decorators and scenic artists, and also because it can be placed with some certainty that it will not be changed. It may also provide sufficient light for a first camera rehearsal. Because the microphone boom must have a virtually unrestricted area of operation, the instruments comprising the base light are ordinarily mounted relatively high above the floor. Heights vary, averaging between 9 and 11 ft, but on some sets where additional clearance may be needed for camera cranes or other equipment, the instruments may be mounted 15 ft or more above the floor. Scoops are mounted on 4- to 8-ft centers (with 4 to 6 being most common) in black-and-white studios. For color they are often mounted almost edge to edge.

Scoops are usually angled toward the floor so that little direct emanation from the lamp strikes the walls of the set to cast shadows of microphones or actors. When possible, scoops are set at a horizontal distance of roughly 10 ft from the edge of the playing area. Light then strikes the plane of the actors' faces at approximately 30°. In most instances only a single row of scoops is used regardless of set depth.

Fall-off of light intensity in the vertical direction from instruments placed as described above is not discernible on camera since light strikes the performer at a relatively small angle. There is, however, an intensity fall-off in deep sets which must be compensated for by the video-control operator or by using dimmers. If the burden of lighting for acceptable pictures is borne by the key light, however, this fall-off of base light is of relatively minor importance and an adequate intensity may be maintained on the actors through careful placement and dimming of the key lights.

Plotting Lights

It is evident that in any situation in which there is only limited time in the studio for lighting and rehearsal as much planning as possible must be done in advance. Consequently, when possible, lights are plotted on scale ground plans of the studio and set. In the network studios these plots are usually made on tracings or on Ozalid copies of the designer's ground plan. It is usual to have a show about 90% plotted before going into the studio and to leave the rest until actor and microphone boom positions can be determined precisely. Occasionally, shows cannot be plotted in advance and the lights are mounted according to the lighting director's instructions as the set is being erected.

Since lighting is to a large extent a subjective operation, each lighting director will plot and mount lights in sequences suited to his own philosophy of lighting. Seldom is the key light mounted first, and often it is not set until after observing a rehearsal in the studio. Set lights are very important in establishing the character of the lighting and are sometimes set first. Problems of flare and proper angle for good separation without objectionable highlights have caused some lighting directors to give priority to the back lights.

In dramatic lighting there are many ways to light a scene for any particular camera angle, but lighting that is effective for one angle will rarely be equally effective for any other angle. Realizing this, cinematographers have varied their lighting whenever necessary for each shot, especially in close-ups, a practice which is impossible in live television. As a consequence, lighting will generally be best when camera angles on any particular area are restricted to roughly the same direction. This is not always possible, and when wide-angle and reverse-angle shooting are employed, the probable effectiveness of the lighting is jeopardized. There is little which either the lighting director or video-control operator can do to minimize the apparent changes of lighting on subjects when this type of shooting is employed.

In lighting scenes on which wide-angle shooting is to be used, it is often helpful to use so-called Rembrandt or three-quarter lighting in which key light strikes the performer at a horizontal angle of 45°. The light then wraps part way around the "off" side of the face to help in video setup and to give picture detail. Even this method of lighting, however, cannot correct for changes in the picture caused by the different backgrounds which result from wide-angle shooting.

It is generally true that the most pleasing results will be obtained when the number of lighting instruments is kept to a minimum, thus reducing hot spots and multiple shadows. As more spotlights are used, not only is the probability of creating hot spots by overlapping beams increased, but, since each beam casts a shadow of any object before it, an objectionable series of shadows may be produced. It is sometimes possible to use a large Fresnel follow-spot as a key light rather than a series of smaller fixed instruments. As the actors move about the set, they will be keyed uniformly without hot spots or multiple shadows.

In the lighting of shiny objects such as automobiles for commercial display, it is usual to use one or two powerful instruments carefully positioned to prevent specular reflections from being seen by the camera. For smaller objects, it is sometimes useful to construct a tent of sharks-tooth scrim with a small port for the camera lens. Lighting instruments shining through the scrim give an extremely diffused light. Indirect lighting by reflection from white sheets or flats may also serve this purpose.

Low-Key Lighting

Lighting directors probably enjoy lighting in low-key more than any other way. Paradoxically, however, scenes of this type are the hardest for the system to handle, and unless skillfully done the results may be disappointing. Low-key lighting is designed to enhance a particular effect of a scene through the use of light. It is often associated with a somber or threatening mood, but, in addition, scenes which result when a light switch is supposedly turned off on a high-key set must usually be treated in the same manner as low-key scenes.

Low-key is typified by dark backgrounds against which the actors are lighted more or less normally. In most instances a single specific source of light seemingly illuminates the scene, but since a single source would not give sufficient coverage, instruments are placed to approximate the direction from which the motivating light shines. In any low-key scene it is important that all essential movements and scenic details be visible, and it is advisable to keep a low-intensity base light to make shadow areas faintly transparent. In the final analysis, the control-room monitor must be the final evidence of the adequacy of the lighting.

It is helpful to the video-control operator as well as effective scenically to use

projections on the walls of a low-key scene, since the television system does not reproduce large unrelieved dark areas well and since the projected highlights serve as a reference for video setup. These projections may be made by the methods discussed under set light.

In working with low-key scenes, it is often necessary to degrade picture sharpness by defocusing the image-orthicon tube. When a camera is properly set up, one or more light-colored orth spots are brought into sharp focus. On a high-key scene these spots go unnoticed, but against the dark backgrounds of a low-key scene they may be objectionable. To eliminate these spots, the image orthicon must be defocused slightly, causing a degradation of the picture.

Another effect which is most noticeable in low-key scenes is an apparent shading of light across the picture due to variations in response on different parts of the tube. When this response pattern is superimposed over a low-key scene, it tends to lighten shadow areas, often in corners and along the edges of the frame. There is little that can be done to correct for this variable shading.

Camera Three (WCBS) is an excellent example of a show staged in low-key. Light is used with a minimum of scenery to set mood and locale — or many times to create the impression of an infinite void. The studio is surrounded with a cyclorama of pale-blue sharkstooth scrim over blue canvas on which light patterns are projected using 750's and cookies or ellipsoidal spotlights. Acting areas are restricted and each is lighted with two or three 750's. There is no base light as such, the fill light coming from spill from other lights and reflections from the floor. Light levels range from 50 to 80 ft-c and *f*-stops are from 3.8 to 5.6.

Conclusion

It is not suggested that these notes are at all exhaustive or conclusive, but rather they give a body of material based on current network practice which may be used as the basis for effective television lighting. With experience, lighting directors will find that they must vary one or more of the suggestions to fit particular shows but that the majority of their lighting can profitably follow the practices outlined here.

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motion-picture standards

Two Proposed American Standards

PH22.89

A Proposed American Standard, PH22.89, Scene-Change Cueing for Printing 16mm Motion-Picture Film, is published here for a three-month period of trial and comment.

This proposal was initiated in June 1944 by the Laboratory Practice Committee as a proposal to standardize the location of the notch used to actuate the printer light change mechanism. It was realized that the lack of a standard led to inefficient and costly practices: for the subsequent notching of a negative as it went from laboratory to laboratory eventually destroyed its use. However, notching practices and equipment were too firmly established to permit standardization of any one given notch location and it became apparent that an industry-wide standard would have to be based on a completely new cue-sensing system.

In 1948 an electronic cueing system was proposed which depended upon the electrical conductivity of a dab of metallic paint. While this new system gave much promise, it was not as consistent or foolproof as a notch. Nonetheless, it presented a potential alternative to the costly notch and many started development work to perfect the idea. By 1953–54, much experience had been gained with this new system. During this period adhesive-backed metallic foil was brought onto the market and was found nicely applicable to this system.

As the new cueing technique proved its practicability, the question became one of standardizing the dimensions and location of the conducting spot. Four separate drafts were required before agreement was reached within the Laboratory Practice Committee. The fourth draft was subsequently approved by the Standards Committee and is the one published here for trial and comment. This new system has the following advantages:

(1) It permits any laboratory to use the cue spot placed on by some other laboratory.

(2) It permits the ready removal and relocation of cue spots placed on by other laboratories without film mutilation.

(3) During the change-over period, it permits the use of negatives already notched without any further deterioration of the negative.

All comments should be sent to Henry Kogel, Staff Engineer, prior to July 15, 1957. If no adverse comments are received, the proposal will then be submitted to ASA Sectional Committee PH22 for further processing as an American Standard.—*H.K.*

PH22.112

Proposed American Standard, Picture-Sound Separation in 16mm Magnetic Sound Projectors, PH22.112, is published here for a three-month period of trial and comment. This proposal is an outgrowth of a proposed revision of PH22.87-1953, Dimensions for 100-Mil Magnetic Coating on Single-Perforated 16mm Motion-Picture Film. The magnetic coating proposal was published for trial and comment in the February 1957 *Journal*.

The revision of PH22.87 was undertaken for two reasons: (1) to make it into a purely magnetic-coating standard and (2) to initiate a separate standard containing a 28-frame picture-sound separation rather than the 26 frame separation contained in the 1953 standard. The 26-frame separation is the standard for photographic sound recording and was found to be perfectly satisfactory for magnetic sound recording as well until new developments and applications of this medium made combined use of both media on one film very desirable. The design of sound projectors to reproduce both recording media would be appreciably complicated if the sound take-off point were the same for both. It was this consideration, of considerable economic significance, as well as international opinion along these lines which became the motive power for establishing a two-frame differential in the picture-sound separation of the two media, both on the film itself and for the sound take-off points in the projector.

All comments should be sent to Henry Kogel, Staff Engineer, prior to July 15, 1957. If no adverse comments are received, the proposal will then be submitted to ASA Sectional Committee PH22 for further processing as an American Standard.—*H.K.*

Proposed American Standard

Scene-Change Cueing for Printing 16mm Motion-Picture Film

PH22.89

1. Scope

1.1 This standard specifies the dimensions, location and nature of a scene-change cueing spot for actuating the printer light-change mechanism when printing 16mm motion-picture film.

1.2 This standard is applicable to 16mm film with perforations along either one or both edges. The dotted perforations in the diagram indicate the edge which varies in this respect.

2. Dimensions and Location

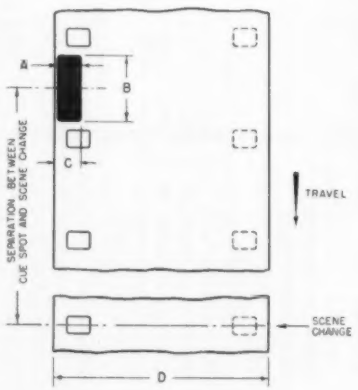
2.1 The dimensions and location of the cueing spot shall be as given in the diagram and table.

2.2 The cueing spot shall be placed 12½ frames after the scene change with respect to the direction of film travel through the printer.

2.3 The cueing spot shall be placed on the emulsion side of the film.

3. Nature of Cueing Material

3.1 The cueing spot shall consist of an adhesive-backed metallic foil rounded at all four corners.



Dimensions	Inches	Millimeters
A	0.070 max 0.065 min	1.78 max 1.65 min
B	0.225 max 0.190 min	5.72 max 4.83 min
C	0.080 max 0.075 min	2.03 max 1.90 min
D	0.628 nom	16 nom

NOT APPROVED

Proposed American Standard

Picture – Sound Separation in 16mm Magnetic Sound Projectors

PH22.112

1. Scope

1.1 This standard specifies the picture-sound separation of 16mm motion-picture film with perforations along one edge and with a magnetic sound record on a 100-mil width magnetic coating. (The magnetic coating is specified in American Standard PH22.87-1953, Dimensions for 100-mil Magnetic Coating on Single-Perforated 16mm Motion-Picture Film, or the latest revision thereof.)

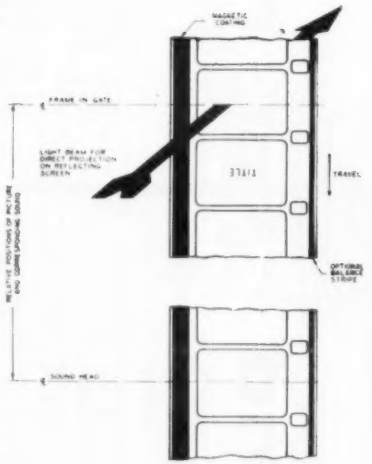
1.2 This standard specifies the location of the magnetic reproduce head in the projector.

2. Picture-Sound Separation

2.1 The magnetic sound record on the film shall precede the center of the corresponding picture by a distance of 28 frames.

3. Location of Magnetic Reproduce Head

3.1 The magnetic reproduce head shall be located 28 frames ahead of the picture aperture as measured with a film threaded in the projector in a normal manner. Thus, at any instant the sound corresponding to the picture frame being projected at that moment shall be reproduced from a point on the film which has passed the picture aperture 28 frames previously.



APPENDIX

When the projector contains an optical-photographic sound-reproduce system with the optical scan point 26 frames ahead of the picture aperture, the magnetic reproduce head is located two frames more distant from the picture aperture. Thus, a given point of the film will pass the optical scan point before reaching the magnetic head.

NOT APPROVED

news and reports

International Photographic Exposition 1957

This spectacular show, which was held in the Washington, D.C., Armory March 22–31, was claimed to be the largest exhibition of photographic equipment ever held in this country. For the first time in the history of the Armory, scene of many expositions in the past, the two floors of the building were entirely filled with exhibits showing just about every phase of photographic technology in this country and abroad.

The main emphasis was on still photography, but since practically every company having any interests in the field was represented there was a fair sampling of motion-picture equipment included. The largest and most conspicuous display was that of Eastman Kodak, in which every area of Kodak activity was featured, including an impressive display of laboratory equipment. General Electric, Westinghouse, Du Pont, Ansco, Sylvania and many others having a stake in the motion-picture industry were well represented.

Of particular interest were the group displays organized by the French and German photographic industries. In the French booth, for example, the products of no less than 29 French companies, making everything from zoom lenses for TV cameras to magnetic striping machines, were assembled in a very striking display.

As was announced in the January *Journal*, the Society had decided to use this occasion to set up a display of its own, illustrating its various activities and areas of service to the industry. The SMPTE booth, designed to be readily transportable and useful at other such occasions as well as at the Society's own conventions, featured a colorful backdrop of lightboxes showing three scenes from the SMPTE 35mm Color Television Test Film and some resolution targets from other SMPTE test films. Beneath these, an open ring binder displayed the Society's work in the field of motion-picture standards, and, more particularly, the Standards Binder Service that it makes available. To each side, pegboard panels showed the many publications and reprints the Society has to offer, as well as membership information and a map showing the location of the nine SMPTE Sections in the U.S. and Canada. On two separate counters, which form a part of the display, folders about the Society and a selection of representative reprints, catalogs and other publications were available for visitors to examine and take away.

Since the Exposition was open afternoons and evenings for ten days, the job of keeping the SMPTE booth properly manned at all times with people equipped to tell inquirers adequately about the Society was not a light one. That the Society was able to undertake such a project at all was entirely due to the sterling help and long hours freely given by members of the Washington Section. Joe Aiken, in the midst of his multifarious duties as Program Chairman for the Spring Convention, nevertheless found time to do two half-day stretches at the booth, as did Ted Braun, Henry Fisher, Dominic Galminas, Bob Griffin, Jack Greenfield, Carl Markwith, Al Moses and Joseph Schantz. Keith Lewis helped greatly with the arrangements for scheduling all these helpers. Any benefits that the Society may derive from its participation in the Exposition will certainly be the direct results of the loyal efforts of all these gentlemen.—*D.C.*

Gordon Yoder Wins NPPA Award

Gordon Yoder of Dallas has been named "Newsreel Camerman of the Year" in the 14th Annual News Pictures Competition and Exhibition held in Washington, D.C., March 22–26.

Yoder, staff cameraman for Telenews in the Southwest, is an active member of the SMPTE and operates Professional Cine Products in Dallas. He has been a member of Cameramen's Local 666, IATSE, for the last 11 years.

The Texan won first prize in the news category for his newsreel story, "Mansfield: Texas Segregation Violence." He also won first prize in the sports category for his "AAU Diving Meet," and second prize for his "Milk Bowl Football." The awards were judged on the basis of story content, camerman's approach to story, and technical skill.

Sponsored jointly by the National Press Photographers Assn. and the *Encyclopedia Britannica*, the contest is the largest of its kind in the world. The award for "Cameraman of the Year" carries with it a $500 U.S. Savings Bond and a set of the *Encyclopedia Britannica*. For the individual prizes, Yoder received a $250 Bond and a set of junior encyclopedias.

A third-generation Texan, Yoder began his career in a motion-picture laboratory in his native Dallas in 1938. He was a newsreel cameraman for Paramount News before serving 2 years in the Army. During the first year of the Korean conflict, he was Paramount News' war correspondent landing with the Marines at Inchon. In 1952 he began supplying films both for Telenews' daily television releases and for MGM's *News of the Day* footage. Ten years ago Yoder covered the Texas City disaster and in 1956 he covered both political conventions. Although his headquarters is in Dallas, all of southern United States is his territory.

The films which won him the NPPA award were taken during the riots which erupted when negroes tried to attend the Mansfield High School. Yoder's camera was smashed by an angry mob and he was ordered from the scene. He left finally only when he had to rush to the Dallas airport to put his films on a New York plane for processing. An incident in the film showed a rioter taking off his straw hat and pushing it into Yoder's camera lens.

The AAU diving championship pictures were filmed at the Shamrock Hotel pool in Houston in the summer of 1956, and the Milk Bowl pictures were taken in San Antonio last December. Both stories were voiced by Harry Wismer to whom Yoder supplies the film for the weekly sports telecast, *This Week in Sports*.

Other prizewinners in the national newsreel competition included Maurice Levy, National Broadcasting Co., second prize in the feature category for his film, *Watching All the Girls Go By*.

Ken Martin, of WBAP-TV in Fort Worth, won honorable mention in the news category for his *Cave-in*, a picture story of a ditch-digging disaster last year in Dallas.

George A. Smallsreed, Jr., chief photographer of the *Columbus Dispatch* won the title "Newspaper Photographer of the Year."

A. Aubrey Bodine of the *Baltimore Sun* was named "Newspaper-Magazine Photographer of the Year." Howard Sochurek was named "Magazine Photographer of the Year."

A total of 175 stories was entered by 58 newsreel cameramen; and 4,262 prints and transparencies were entered in the still picture category by 418 press photographers.

Academy Engineering Awards

Seven of the eight individuals who received Academy Awards for Scientific or Technical Achievement are SMPTE members, and three of the firms cited, Consolidated Film Industries, Paramount Pictures Corp. and Republic Studios, are Sustaining Members.

The Awards were voted by the Board of Governors of the Academy of Motion Picture Arts and Sciences from recommendations made by the Scientific or Technical Awards Committee. There were no Class I or Class II Scientific or Technical

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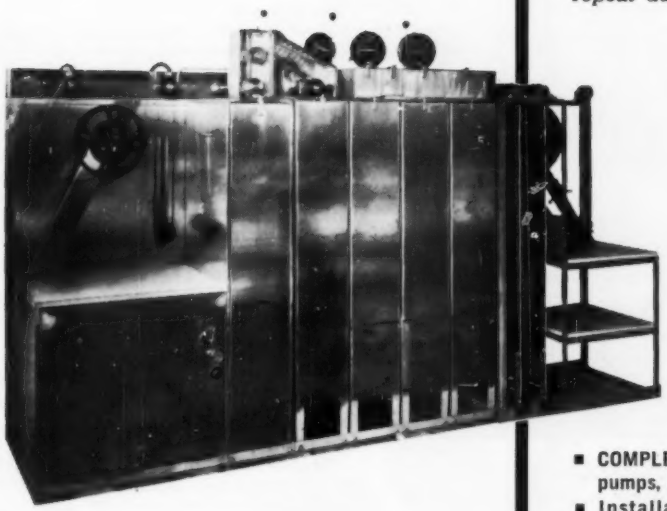

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Awards voted by the Board this year. Class III Awards follow:

To Richard H. Ranger of Rangertone, Inc., for the development of a picture-synchronous recording and reproducing system using quarter-inch magnetic tape, without sprocket holes.

To Ted Hirsch, Carl Hauge and Edward Reichard of Consolidated Film Industries for an automatic scene counter for laboratory projection rooms, permitting the laboratory technician to identify each scene by number during the screening of a print for timing corrections.

To the Technical Departments of Paramount Pictures Corp., for engineering and development of the Paramount lightweight horizontal-movement VistaVision camera.

To Roy C. Stewart & Sons, to Dr. C. R. Daily and to the Transparency Department of Paramount Pictures Corp., for the engineering and development of the HiTrans and Para-HiTrans rear-projection screens. These new process screens provide a much higher light transmission and reflect far less front spill light than earlier types of screens. Uniform and reproducible characteristics are obtained by improved manufacturing techniques.

To the Construction Department of Metro-Goldwyn-Mayer for a new hand-portable fog machine which operates from light, quickly replaceable Propane gas tanks. It is self-contained, has a large capacity and a wide range of output volume.

To Daniel J. Bloomberg, John Pond, William Wade, and the Engineering and Camera Departments of Republic Studios for the Naturama adaptation to the Mitchell camera. The Naturama precision adaptor provides Mitchell cameras with an anamorphic attachment lens and a single remote control unit which insures simultaneous focusing of the anamorphic lens with the regular Mitchell camera lens.

The Academy Board of Governors expressed its appreciation to each member of the Scientific or Technical Awards Committee and Subcommittees making the recommendations, for their cooperation and assistance in this year's consideration of the entries. The committees included:

John O. Aalberg, *Chairman*, Daniel J. Bloomberg, John W. Boyle, Daniel B. Cathcart, Charles R. Daily, R. H. Duval, Farciot Edouart, Ferdinand Eich, Glenn Farr, Feild Gray, Sol Halprin, William Hornback, G. Carleton Hunt, John P. Livadary, Louis Loeffler, William Mueller, Charles Rice, Gordon Sawyer, Sidney P. Solow, Clifford Stine, Jack Tait and Byron Vreeland.—*R. H.*

(*We are indebted to Dan H. Baer of the Los Angeles Office of Harshe-Rotman Inc. for the basis for this report.*)

SPE + TD(PSA) = SPSE

A communication from Edward S. Cobb, 1201 Valley Ave. S.E., Washington 20, D.C., announces the consolidation of the Society of Photographic Engineers, Incorporated, P. O. Box 6077, Mid-City Station, Washington, D.C., and the Technical Division of the Photographic Society of America which has been under the editorial direction of Paul Arnold, APSA, 26 Hotchkiss St., South Binghamton, N.Y. The consolidation will create the Society of Photographic Scientists and Engineers.

Under the new masthead "Photographic Science and Engineering," the Society will continue to publish its technical journal. Each subscription will cover one volume consisting of four issues. Two issues of Volume 7 of "Photographic Engineering" remain to be published. These will be sent to all 1956 subscribers.

Subscriptions in 1957 will apply to the next volume. The journal is not issued quarterly and the first number of the next volume will be published about July, 1957. New subscribers will receive all four numbers of the volume, regardless of date of issue.

Back issues are now available at $5.00 each for volumes 1 through 5, and at $8.00 each for volumes 6 and 7. After present stock is exhausted, back numbers will not be reprinted.

Biographical Note

Mervin W. La Rue, Sr., Honored as SMPTE Pioneer in 1954 and by BPA in 1956

[*Editor's Note: This biographical note was prepared by Mervin W. La Rue, Jr., at the Editor's request. The intimate details and informal anecdotes contribute to a delightful picture of a certain segment of motion-picture history. Mervin W. La Rue, Sr., who perhaps may still be described as "the young photographer," is now the president of the company, specializing in medical films, that bears his name.*]

Mervin W. La Rue, Sr., was born July 6, 1892, in Bound Brook, N.J., the eldest son of Adella Worthington and William B. La Rue. According to a family anecdote a Christmas gift of a box camera when he was a young boy was the turning point in his life, or at least a contributing cause to his choice of a career.

During summer vacations from high school he worked for the local photographer, but at the time must have felt this was not a very promising future, since many of his studies were directed toward a teaching career in manual training. During this period he won several prizes as a result of his skill in wood carving.

His career really began at the age of 20 when he joined the New York firm of Underwood and Underwood as assistant to a staff photographer. The assistant's duties consisted mainly of carrying the photographer's luggage but the youthful assistant eventually convinced the management that he deserved a trial as a photographer on his own.

He left the studio the first morning with assignment sheets for about ten or twelve hours of work, and just out of apprenticeship he himself carried all the equipment and supplies needed for the day. All went well until he received a late evening assignment for a flash picture of elevator equipment in a sub-basement. It was well after working hours, all lights were out, and the basement was dark. Anxious to finish, he focussed the camera by candlelight, generously sprinkled flash powder into the open flash gun, and fired it off directly under a fire sprinkler head. Later, while firemen were pumping out the basement, he was back at the studio developing the plates in his shorts. The next day his appointment was confirmed, which he now describes as a brilliant form of discipline he has never completely understood.

Much of the work here was just what an adventurous young man must have wanted. One assignment was the photographic recording, for the Roebling Company, of the methods used in erecting the new steel building frameworks which were supplanting the older stone-on-stone building methods. This involved climbing around in empty air hundreds of feet over New York City, while carrying the bulky and heavy equipment needed for the job. It was in between assignments of this sort that he became acquainted in 1913 with the young lady who later became Mrs. La Rue, and who at that time was secretary to one of the company officers.

His immediate goal at that time was to become a motion-picture cameraman, and he obtained a job in the Pathé Studio after assuring them that he could "do anything with a camera."

He soon learned that this took in a little too much territory, and the next day Pathé started him out in the "salt mine" where he spent twelve hours a day winding film on wooden racks prior to processing. This was in 1915. From there he progressed to negative developing, printing machines, title photography, print-assembly, and then was selected to work with one of the first developing machines. This was a complicated arrangement of vertical pipes through which the processing solutions were circulated. Temperature control of the solutions was obtained by keeping one whole section of the machine in a meat refrigerator, a procedure also reported to help keep the tempers of the operators cooled down to a proper working temperature. A system of lights and buzzers on this nearly block-long monster warned of film breaks and buckles. Considerable speed and dexterity were required to clear trouble without stopping the machine, and the operators all wore track or tennis shoes so that they could get away to a fast start.

During this time there were opportunities to visit other departments, and possibly as a result of the interest he displayed in other operations, he was given the job of photographing a new trailer trade-mark for Pathé — the crowing rooster. A velvet-lined box with a glass face secured the rooster, and with the equipment ready to go all was well except that the rooster

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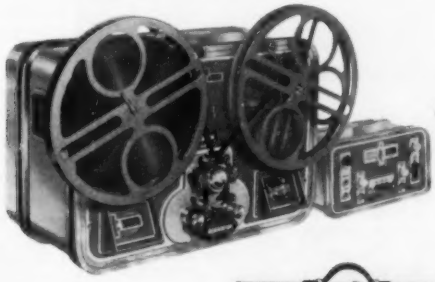

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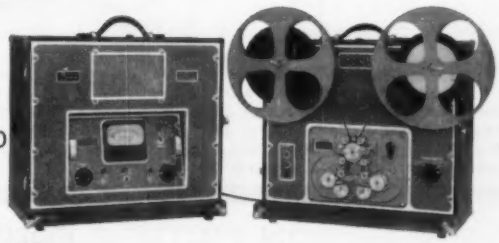

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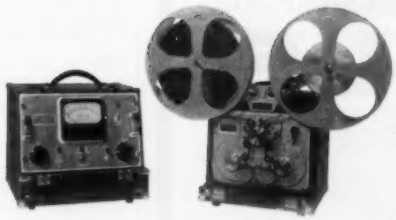

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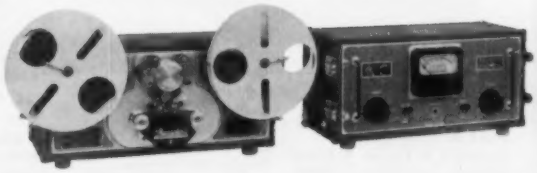

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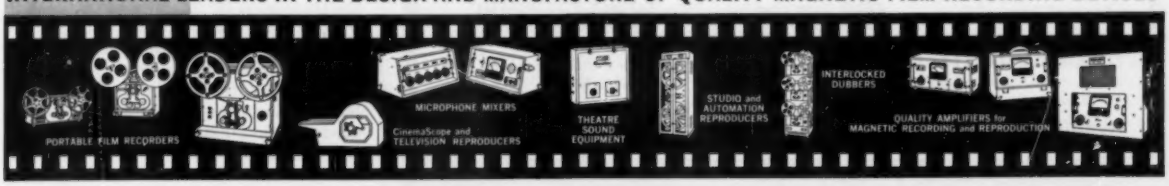

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would not crow. After using almost every device known that might supply the necessary encouragement, he finally decided to wait for dawn, and perhaps bring a hen or two into the act. During these difficulties the usual assortment of kibitzers contributed helpful hints.

While the discussion about the non-crowing rooster continued among friends and well-wishers, the young photographer was called away. Upon his return he was informed that the scene was made and all he had to do was develop the negative. The scene was perfect, but the successful kibitzer would not tell until much later how it was done. Eventually it was learned that a loop of thread around the rooster's neck, pulled tight when a crow was wanted, had done the trick. The rooster wasn't crowing, he was choking to death; a prime example of movie trickery.

The next major change was in late 1916, from the Pathé Studio to Pathé News; and after convering news and magazine assignments in the United States for a time, he was transferred to Canada on a roving assignment. Canada was at war then, and news assignments were plentiful. When the United States entered the war in 1917, things became confused. After reporting to the American Consul and to New York headquarters, La Rue found himself with a briefcase bulging with papers and an assignment as instructor in aerial photography at Camp Borden, Ontario, where United States fliers were to be trained. By his own report, no one else seemed to know very much about aerial photography either, so he managed to keep out of difficulty for the duration.

There was much traveling involved during and after the war, including several trips abroad — but during all this confusion, he was able to persuade his fiancee to come to Toronto, where they were married.

He was covering all outstanding events in Canada during this time, the most strenuous being the official tour of the Prince of Wales (the present Duke of Windsor) through Canada and the United States. He lived on the royal train for the entire tour of six weeks, through New Brunswick and Nova Scotia to British Columbia and return.

His first venture into the field of medical photography occurred in Toronto where Dr. Banting and Dr. Best were doing the work that led later to the discovery of insulin as a treatment for diabetes. With a newsman's sure instinct he sensed that important developments were taking place at the University. He interviewed Dr. Banting who, with the caution typical of the man of science, refused to permit any publicity until the results of the experiments had been verified. The doctor and the photographer, however, worked out a "deal." Dr. Banting needed a special kind of assistance with his experiments. He promised his help with the news reel when the time came for the announcement, provided the young news photographer would help him by photographing the rats used in the experiments. This chance assignment probably led to his continuing interest in motion-picture photography as a tool of medical science and hence to some important developments and discoveries reflected in the increasing life

expectancy of today as compared to even a generation ago.

The first surgical move he made was certainly unusual as compared with today's methods. He has described the experience as follows:

"Soon thereafter, I was asked to make a movie of a surgical procedure in the Toronto General Hospital. Remember that all we had at this time was color blind film of one speed — slow — and the only artificial light source was open arc. They used open drop ether, so for the safety of the operating personnel and cameraman — as well as the patient — this made it necessary to support a "sun-arc" on a scaffold erected outside the skylight in such a manner as to permit its being focused on the surgical area during the operation. We worked out a system of signals so that I could direct the electrician in focusing the light should it become necessary during the surgical procedure.

"They mounted me on a metal stepladder over the head of the patient where they perhaps thought I would be out of the way. I did not know any better, so during the procedure managed to absorb a great deal of ether meant for the patient. Shortly after things got under way, someone moved the operating table and the electrician refused to acknowledge my frantic signals for adjustment. It was only later that I learned he could not see a thing because the reflection of the arc on the glass soon blinded him to what was going on inside.

"Somehow I kept turning the camera crank — as slow as I could to increase the exposure time without making the action too fast — but I do remember sliding down the ladder and leaving the operating room on all fours when told that I could do so. I was draped over the balustrade taking in all the fresh air possible when the surgeon appeared behind me and invited me to have lunch with him. That did it — and so once in my life I had to turn down a free meal.'

During a trip to England, he, by chance, became acquainted with J. H. McNabb, then president of Bell & Howell Co., who invited him to spend a week-end in Chicago. Shortly thereafter he was offered a position with the firm beginning in October 1926. The project for which he was hired involved setting up the new processing equipment and methods required by sound motion pictures in laboratories throughout the country. This was a time of great change in the industry. The Bell & Howell firm aided many laboratories to change from their ancient rack-and-tank methods to controlled machine operations almost overnight. During this period he also directed several films including what is believed to be the first all sound medical film. This was sponsored by the Eli Lilly Co. and was designed to bring the story of insulin, including the details of its use, to the medical profession.

By 1931, laboratories and producers were familiar with the new techniques of sound motion-picture production, and industry was beginning to see the educational and sales potential of sound movies. The way was paved for the later acceptance of Bell & Howell's 16mm sound movie equipment. The Bell & Howell project was completed about the time that the depression was

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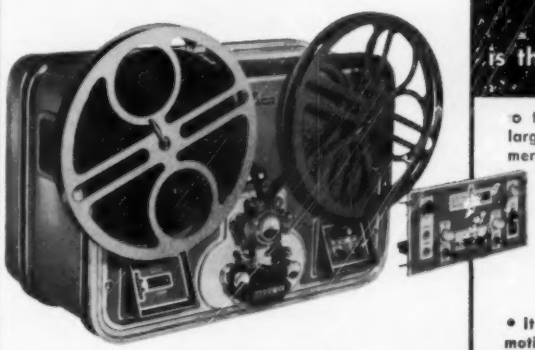

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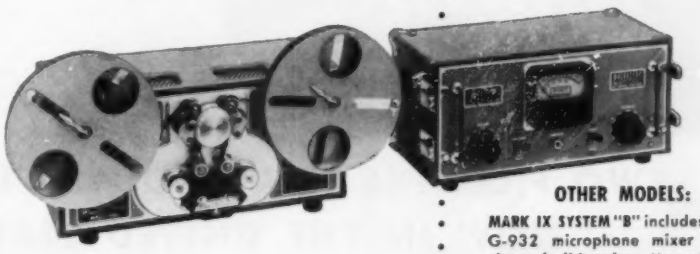

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catching up with business in general. La Rue left Bell & Howell and went with Burton Holmes Films as a "one man band" — salesman, writer, producer and cameraman. This might seem an unusual combination of activities, but it suited the talents and ambitions of the rising young photographer. When encountering a new situation, his method was to get all the relevant information possible by means of a course of study in a nearby university, a correspondence school or the nearest public library. His knowledge of selling techniques, for example, was acquired from a correspondence school course.

With the development of 16mm equipment, an increasing number of inquiries arose, relating to the application and adaptation of this equipment to special purposes. Problems in motion study, time-lapse photography, microscopy, and other fields kept coming to his attention, and the experience gained in working out these problems continued to intensify his interest in them. The advantages of motion pictures in the medical field were becoming better known, and work on some medical films began at Burton Holmes Films. However, the production of 35mm films by large producers was a severe handicap to the small budgets of the medical field, great as were the needs for such films. The use of black-and-white film was an additional disadvantage in a field where so much of the information to be transmitted relates to color and texture. These factors, considered along with the rapid improvements being made in color films, resulted in his decision to leave Burton Holmes Films and begin free-lancing.

His confidence in this new field must have been great even then. The move was made in 1936, during the very bottom of the depression, when the expected life of a new business venture was short. This one started out with a purchase of capital equipment consisting of a Bell & Howell "70" camera, three lenses, a 400-ft magazine, a tripod, a few accessories and lamps. While not much of a physical inventory, when combined with a tremendous background, real enthusiasm, and no particular concern about the hours of work, the result was only a few anxious months before things really started to hum.

"The Business," as it is still called, continued to improve and expand until in 1947 it became a corporation. Its scope has grown to include the well-defined functions of production of medical motion pictures and allied types of illustrations, the distribution of audio-visual equipment and, audio-visual consultation to the medical profession. It is certain that the most important factor in its success has been its founder's philosophy that if he gives prompt advice and service wherever there is a need for it, everything will work out all right.

In 1954, at the Society's 75th Convention and Pioneer Awards Session, among the 26 Pioneers was Mervin W. La Rue, Sr., whose citation read: "A 30-year member, Mr. La Rue was a cinematographer with Pathescope of Canada at the time he joined the Society. He has been active in the work of the Central Section of the SMPTE, is a Fellow of the Biological Photographic Association [whose Louis Schmidt award he received in 1956] and has received seven formal awards for medical motion pictures in which he specializes. Since 1916 he has been making motion pictures. Over the years he has been associated with Underwood and Underwood, Pathescope, Bell & Howell, Burton Holmes, Jack Eaton and since 1936 has been known for his development and adaptation of motion-picture techniques to research, to visual instruction and to science." — *Mervin W. La Rue, Jr.*

Automation—A Conference for Executives is a report on an automation conference held Feb. 14–15 in Chicago. The 116-page, illustrated book is priced at $4.50 and is available from the Armour Research Foundation of the Illinois Institute of Technology, 10 W. 35 St., Chicago 16. Remittances should be marked for the attention of MF:AU1.

The 1957 Spring-Summer edition of Television Factbook has been issued by Television Digest, Wyatt Building, Washington 5, D.C. Included in this edition are 75 departments and directories. Under each category complete information, such as names, addresses, phone numbers, facts and figures, is listed. Each book contains a 43 × 29 in. wall map that shows TV stations and networks throughout the United States and Canada. Single copies are priced at $4.50 but in lots of 5 or more, the price is $3.00.

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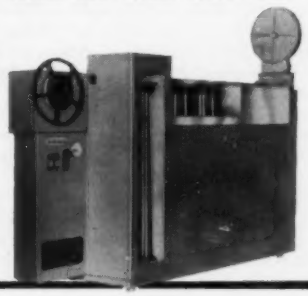

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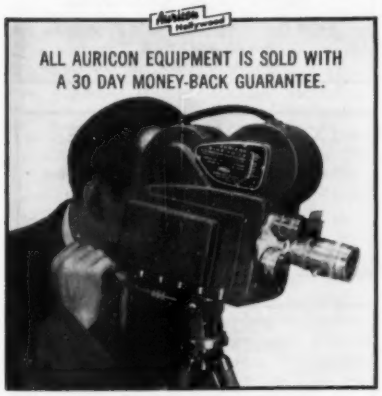

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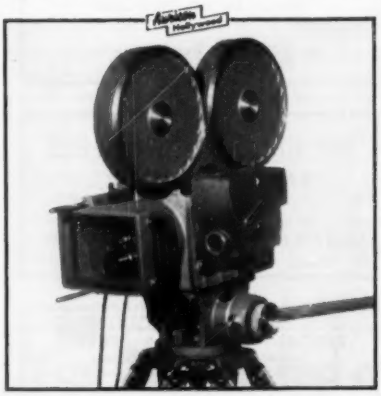

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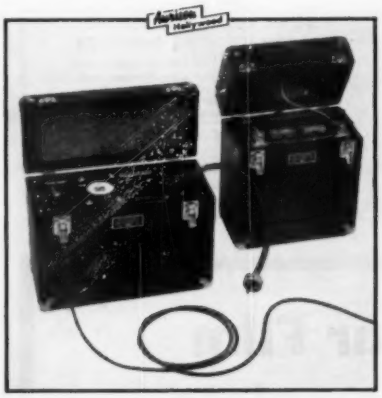

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Education, Industry News

A system whereby new motion pictures will be wired from local studios to home television sets is "the hope of the future of the motion picture business," according to Henry Griffing, President of Video Independent Theaters, Inc., Oklahoma City; but George Manos, theater owner of Toronto, Ohio, as quoted in *Showmen's Trade Review*, March 9, calls the plan "suicidal." Meyer Fine, head of the 25-house Associated Theater circuit, Cleveland, in commenting on the plan said, "Who would go to a theater when they could see the same movie at home? And what would become of our building investments, not to mention our business?"

Mr. Griffing, proponent of the controversial plan, described it on March 7 at the second annual convention of United Theater Owners of America, Oklahoma City. Known as telemovies, or TM, the system is scheduled for a tryout in Bartlesville, Okla., a city of about 28,000. Subscribers would get 13 first-run pictures a month on their TV sets and a given day's program would run continuously for 8 or 10 hours. Mr. Griffing said that he expected to break even on operating costs with 1500 subscribers at $9.50 a month. He emphasized that anyone could use or adapt the idea without payment of royalty or fees. "We're not trying to keep people out of it. We want them to get into it," he said.

Residents of a New York housing development will soon be instructed and entertained by closed-circuit television programs that will reach all apartments in four cooperatively owned buildings operated by the East River Housing Corp.

The four buildings have master TV antennas connected to the individual apartments. The studio will be in the office of the development at 570 Grand St., and the equipment will be rented. The programs, exclusively for the information and enjoyment of the apartment-dwellers will feature discussions of problems and activities affecting them and entertainment will be provided by amateur groups made up of talented individuals residing in the housing development.

The Rochester Institute of Technology has announced five in-service summer courses in photography for teachers: Fundamentals of Photographic Chemistry; Basic Chemistry for Teachers; Workshop in Picture Making; Visual Aids Workshops (2), and a Motion-Picture Workshop. Closing date for registration is May 15. All courses are approved by the Department of Education of the State of New York for in-service training and credit in the areas of professional improvement and related activities.

H. J. Lovell has been appointed to the newly created post of Director of Technical Operations for the WKY Television System, Inc. He will be in charge of engineering facilities for WKY Radio and TV in Oklahoma City, Okla., WSFA-TV in Montgomery, Ala., and WTVT (TV) in Tampa and St. Petersburg, Fla. These stations are owned by the Oklahoma Publishing Co. He has been associated with WKY since 1928 when he joined the station as transmitter engineer; in 1932 he was appointed Chief Engineer.

East-West TV Network, an independent supplier of closed circuit projection equipment, has announced the appointment of nine associate offices. Now making locally available camera chains and crews, as well as new projection equipment designed and built by East-West TV engineers, are:

Trident Films, Inc., New York City; Professional Electronic Products, Inc., Pittsburg; Robert F. Blair, Cleveland; Mike Bowdon, Cincinnati; James F. Mulqueeny, Chicago; Northwest Sound Service, Inc., Minneapolis; Ivo Distributors, Los Angeles; Commercial Electronics, Inc., Dallas; and Mutual Electronic Supply, Inc., Seattle and Portland.

The parent organization is East-West TV Network, 2924 Auburn Ave., Toledo 6, Ohio.

A wall chart of conversion factors is available without charge from the Precision Equipment Co., 3716 N. Milwaukee Ave., Chicago 41. Included are common conversions such as inches to centimeters or watts to horsepower, as well as many conversions that are difficult to locate in reference manuals.

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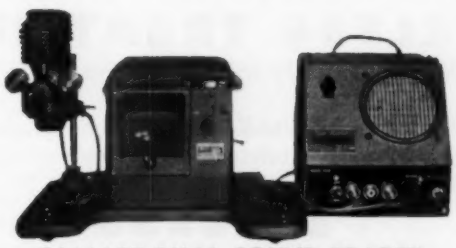

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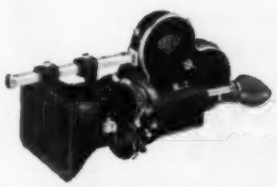

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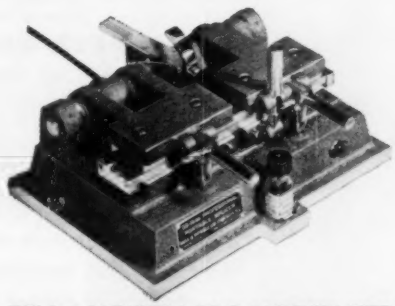

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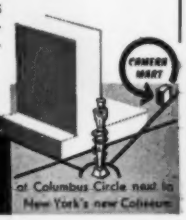

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section reports

The San Francisco Section met February 2 at the Orpheum Theater, San Francisco, with an attendance of 77. Ernest Langley, Resident Engineer, and Walter White, Console Operator of Cinerama conducted a tour of the installation after a showing of the Cinerama Production, *Seven Wonders of the World*. Features of the Cinerama system shown during the tour include the 7-channel magnetic sound reproducer which is the starting point of the system. The three picture projectors are locked through a system of differential selsyns to the sound reproducer. All projectors are controlled by a master console operator who can advance or retard any of them by means of the differential. A series of lights shows when all projectors are in sync, these lights flashing once each 3 ft of film.

An additional set of controls is also on the master control board which allows the operator to control the light output of each projector so that good light balance may be maintained on the entire screen. The projectors are of special design using 35mm film. The aperture is, however, six sprocket holes high, rather than the standard four, and the running speed is 146 ft/min. The combination of the three pictures on the screen gives an aspect ratio of 2 to 1 with an angle of view which closely approaches that of the human eye.—*Werner H. Ruhl*, Secretary-Treasurer, 415 Molimo Dr., San Francisco 27.

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The Hollywood Section met February 19 at the Preview Theater Studio, Hollywood. Approximately 225 members and guests attended. John Olsson, Houston-Fearless Div. of Color Corp. of America spoke on the "Berthiot Pan Cinor-4 Lens and Eclair Camerette Motion Picture Camera." Jack L. Copeland, Jack L. Copeland and Associates, spoke on "Production of the Informational Film *The Invisible Passenger*."

Mr. Olsson placed emphasis on a description of the instrumentation accessories for the Camerette motion-picture camera, including the new Som Berthiot Pan Cinor-4 Lens. This is a new variable-focus lens with a range from 38½mm to 154mm and a lens speed of $f/3.8$ for use on 35mm cameras.

Mr. Copeland showed the 35mm color picture *The Invisible Passenger* which was made for the California Highway Safety Council and the Association of California Insurance Companies. This film dealt with traffic safety and involves unusual and dramatic production techniques, which were explained by Mr. Copeland. The theme of the picture concerned an automobile accident. In order to film this sequence two wrecked cars were obtained and new cars matching them as closely as possible, were used for the earlier sequences. The optical effects work, to simulate the impact of the two vehicles, was described in detail. Mr. Copeland stressed the differences between the production of informational types of films and purely theatrical films.—*Robert G. Hufford*, Secretary-Treasurer, c/o Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38.

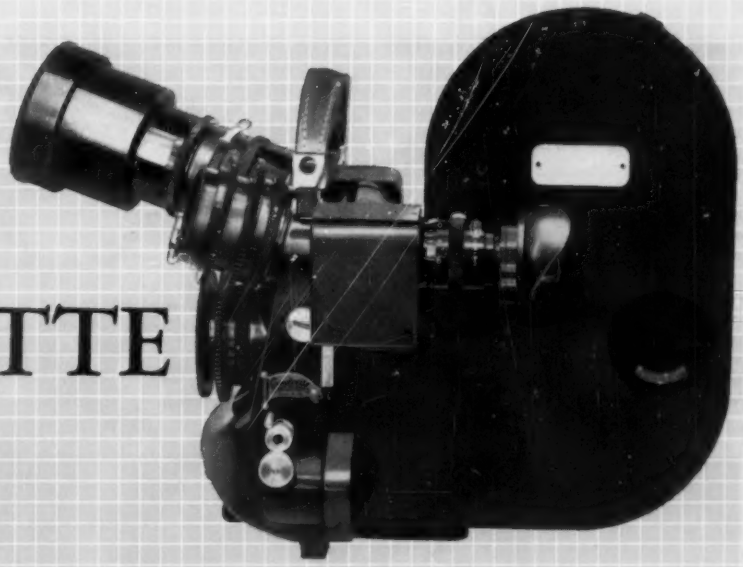
The Rochester Section met on February 21 at Dryden Theater, Eastman House, Rochester, with an attendance of 50. Speakers were John L. Forrest, Ansco, and Dean M. Zwick, Eastman Kodak Co. Mr. Forrest spoke on "A New 16mm Reversal Camera Film," and Mr. Zwick described "The New Intermediate Positive Duplicate Negative System." Both addresses were illustrated with slides and motion pictures.—*A. E. Neumer*, Secretary-Treasurer, 147 Dale Rd., Rochester 10, N.Y.

The Atlanta Section met on February 25 at the Kodak Processing Laboratory, Chamblee, Ga., with an attendance of 60. A. M. Koerner, General Supervisor of Quality Control, Color Processing Div., Eastman Kodak Co., Rochester, N.Y., spoke on "A New Intermediate Film System for Color Motion-Picture Photography." Following the address, members and guests were taken on a tour of the Kodachrome Processing Laboratory. At the close of the program, the Board of Managers met to discuss plans for the coming year.—*C. W. Wood*, Chairman, c/o Eastman Kodak Co., 4729 Miller Dr., Chamblee, Ga.

The San Francisco Section met on March 12 at the West Coast Electronic Labs of Kaiser Aircraft and Electronics Corp. The Director of Research, William Ross Aiken, described the Kaiser-Aiken Thin Kinescope for the 35 members and guests attending the meeting.

The tube, as described by the speaker, uses no deflection yoke, focus coil or ion

CAMERETTE



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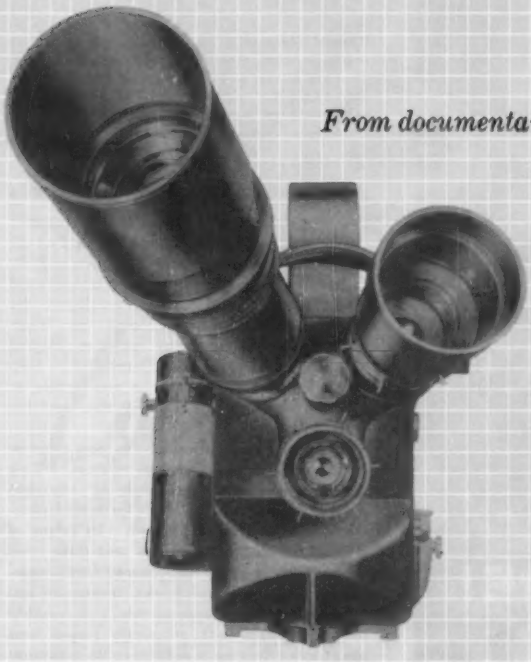

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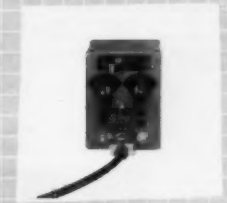

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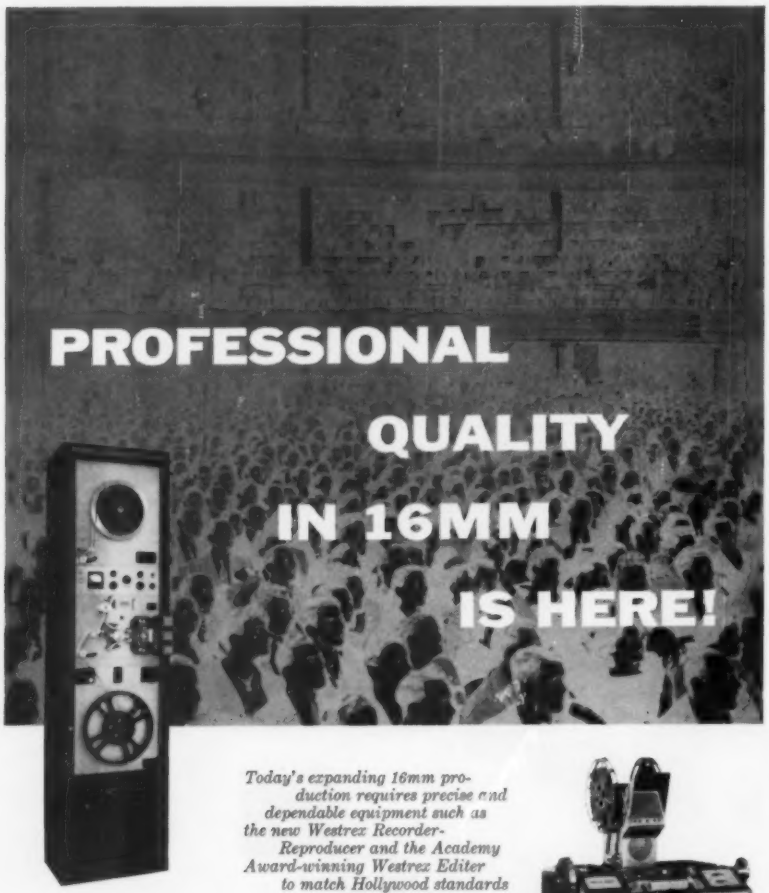
trap and yet it has perfect deflection linearity and a resolving power not found in present kinescopes. The new thin cathode-ray tube utilizes the Aiken Deflection Principle and consists essentially of a phosphor screen and transparent deflection plates within the glass faceplates. The tube functions by electronically exciting selected areas or spots on the phosphor screen. This is accomplished by the following means.

An electron beam is injected along an edge of the tube. This beam flows in a field-free region near the edge of the phosphor screen and adjacent to a row of transverse deflection plates. Through control of the voltages on these deflection plates, the beam is bent vertically at any desired place along the edge of the tube. The beam then flows vertically in a second field-free region between a series of transparent deflection plates and the electrically charged phosphor screen.

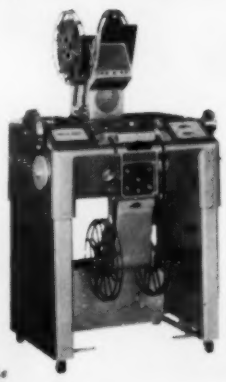
Deflection of the beam into the screen at any desired vertical level is made possible by controlling the voltages on the transparent deflection plates. Through the above means the position of the spot created by the deflection beam may be exactly controlled.

The deflection system employed in the new tube provides extremely fine focus, resulting from the principle involved in the beam dynamics of the tube. As a result, the resolution obtainable is superior to that of conventional tubes, along with a much higher screen brightness.

This tube could well be the prototype for the flat wall tube.—*Werner H. Ruhl*, Secretary-Treasurer, 415 Molimo Dr., San Francisco 27.



Today's expanding 16mm production requires precise and dependable equipment such as the new Westrex Recorder-Reproducer and the Academy Award-winning Westrex Editer to match Hollywood standards and to keep costs down.



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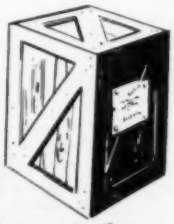

new products (and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

Technirama: A Development for Large Screens

Technirama is a wide-screen system developed by Technicolor Motion Picture Corp., 6311 Romaine Street, Hollywood 38, It has been used in the soon-to-be-released *Night Passage* which was produced by Universal International, and in *Monte Carlo* which premiered at the Riposi Theatre in Turin last December. Two motion pictures presently in production at RKO and Warner Bros. will also use this system.

The chief innovation of this new process is its anamorphic optical system. This system works on the principle of reflection optics, designed by N. V. Optische Industrie of Oude Delft, Holland. In terms of definition, image distortion and flare, this anamorphic system has proved itself superior to all others. Light losses are extremely low. Because of this, it is possible to photograph with relatively larger lens apertures effecting a considerable economy in studio lighting. The Technirama lens is an attachment lens, anamorphic, prismatic and designed to focus simultaneously and in sync with normal 50mm, 75mm, and 100mm lenses. Even at larger lens aperture good depth of field is obtained, and this factor coupled with the intrinsic sharpness of the image and the wide angle of view makes it possible for the movie director to cover the same action with less set-ups than he requires in normal cinematography. Where one would expect an eight-perforation film to consume twice the amount of negative raw stock compared with four-perforation film, less than 60% of negative raw stock is consumed. The cost difference between other methods of 35mm photography and Technirama is reported not to exceed $25,000.

In production, Technirama has proved itself perhaps the most economical of the large negative systems. It employs a standard 35mm negative which moves horizontally through the camera exposing eight perforation frames. With allowance for a standard optical soundtrack, the whole of the remaining negative area

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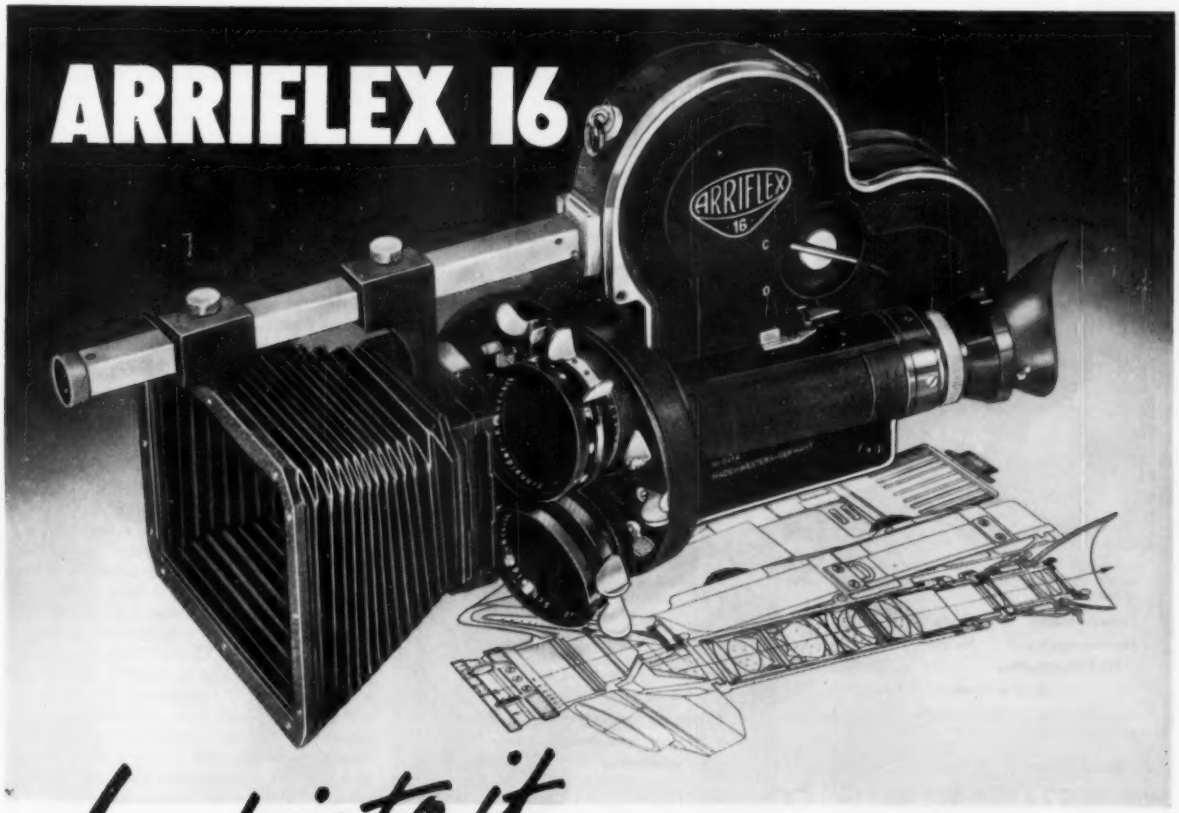
ARRIFLEX 16



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There is the registration pin film movement with micrometer accuracy; the precision film gate with side pressure rail, rear pressure pad and cross stages. Three-lens, oversize divergent turret, electric motor drive, and a host of other features.

The Arriflex 16 is a hand camera. It is also a studio camera if you add the 400 ft. Arri magazine. And it is a sound camera when you use it in the Arri 16 Sound Blimp. The cost is surprisingly little, for a professional camera with precision engineering. The Arriflex will pay for itself in the shortest time, because it is easier to transport, easier to use, more versatile and most reliable.

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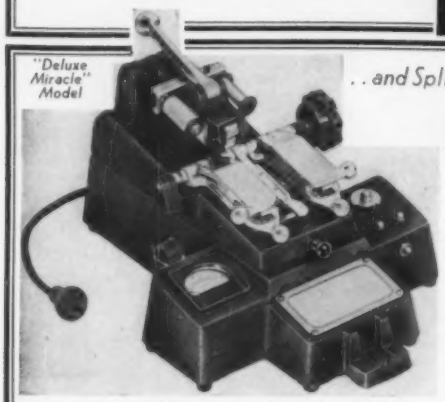

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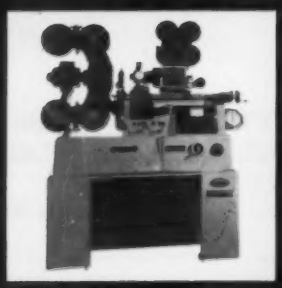

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within the frame is utilized. Other large-screen negatives often waste as much as a quarter of the available area, but a double squeeze CinemaScope-type positive print made from Technirama makes the maximum possible use of the positive frame. Since no area of the available negative and positive frames is lost, Technirama achieves a considerable advantage in terms of definition and reduction of grain visibility.

As the negative runs horizontally through the camera, the picture is recorded in partially squeezed form on a large area double the surface used in standard-frame 35mm film. Compressed 1.5 times in the camera, the image undergoes further compression in printing so that its final compression is 2 to 1.

Processing is carried out in the Technicolor laboratories and anamorphic rush prints in both color and black-and-white are provided. These rush prints have an anamorphic factor of 2 and can be handled by picture editors as though they were CinemaScope prints. The release print, compatible with large-screen projection installations throughout the world, is of the CinemaScope type on standard perforated positive. These prints have a single optical soundtrack and a compressed image which if projected with a CinemaScope-type projection lens will yield an aspect ratio on the screen of 2.34:1. Technicolor Corporation will also manufacture stereophonic-type prints carrying four magnetic tracks and an image projection with a screen aspect ratio of 2.55:1. It is understood also that Technicolor can also make prints conforming to the new "magoptical" specifications.

A number of the Technirama cameras are available for hire. They are equipped with either 1,000- or 2,000-ft magazines, remote focussing controls, blimps and all normal accessories. These cameras make special effects practicable and shortly still other Technirama cameras will be available for high-speed photography. The understanding is, however, that the majority of producers may equip themselves with eight-perforation cameras, all of which can be fitted with the Technirama anamorphic unit.

A special Technirama projector called the "Micronlambda" has been developed by Microtechnica, Turin, Italy. Two picture ratios are required in this projector: A "great picture" ratio similar to the one followed in shooting; and a "standard picture" ratio identical to optical CinemaScope. The "great picture" ratio is 36:11-mm × 22:38mm; the "standard picture" ratio is 21:31mm × 18:16mm.

Although this projector has the components of any common projector, the drive is placed to allow for the film's horizontal travel. Film travels twice as fast through this release system as it does in standard projectors. The Maltese Cross Block, triple the size of standard blocks, has to have a greater resistance since it undergoes greater effort. The shutter system, operated by coaxial shafts, is substantially different. The pre-anamorphic lenses, also, have a diameter of 100 focal length because of the greater surface of the photogram. A ratio of 1.5 is the expansion factor for these lenses, 0.5 less than the usual anamorphic lens. Delrama-type and mirror-like, these lenses achieve definitions impossible with cylindrical lenses.—*R.G.*

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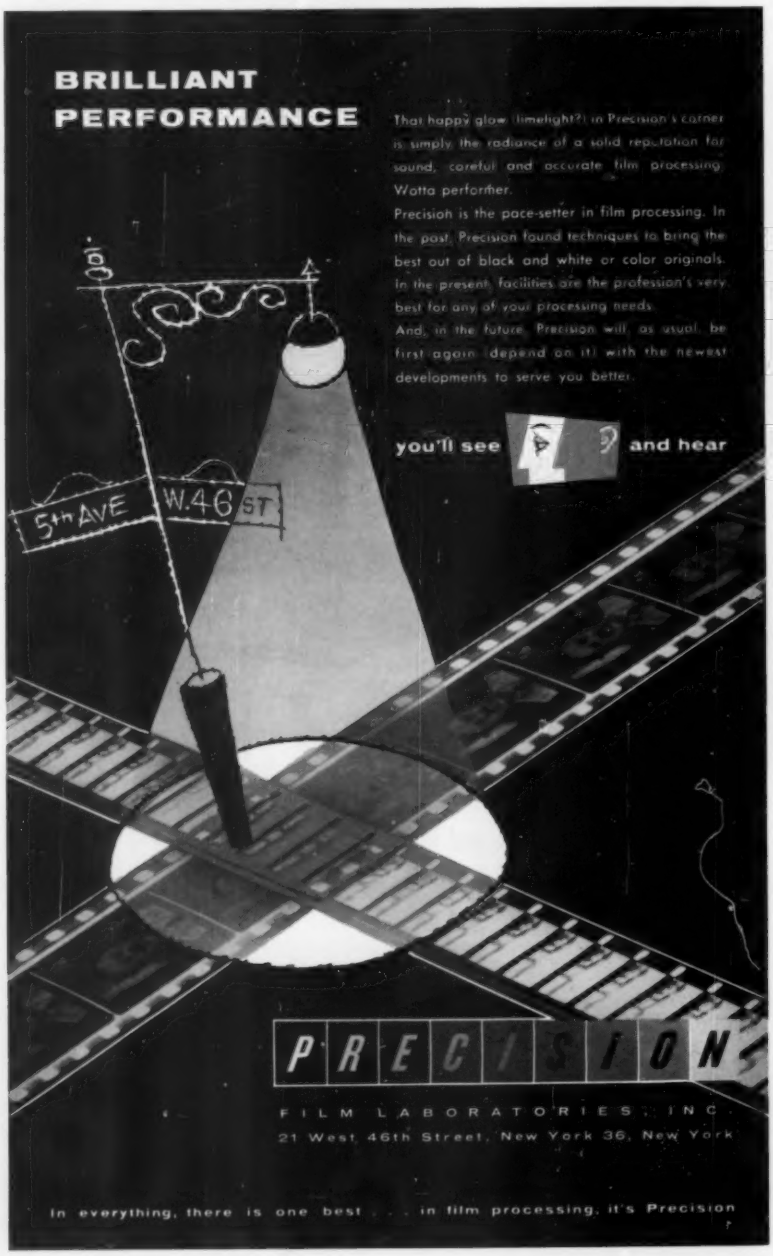
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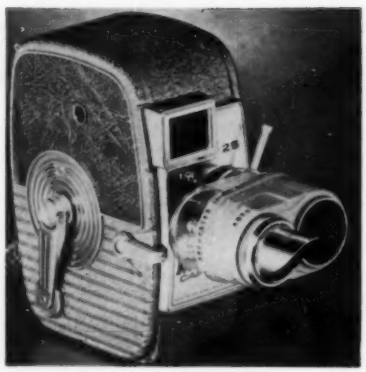
The Auto-Ex is a fast $f/1.9$ lens coupled to an accurate exposure meter. It is made to fit most "D" mount cameras. For correctly exposed color motion pictures the photographer sights his camera, matches two arrows and shoots.

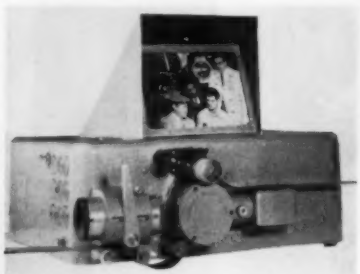
The Auto-EX analyzes light conditions and transmits the information to the floating needle. By lining up the needle with an arrow, all guesswork is eliminated from shooting. Over- and under-exposure can be prevented, and ruining costly color film can be avoided.

The Auto-EX exposure meter is calculated for daylight color film with an exposure index of 10 and tungsten color film with an exposure index of 16. The angle of acceptance of the photocell is designed to



exactly match the angle of the lens. It is ingeniously engineered to permit *intentional* over- and under-exposure depending on whether the subject is light or dark. Manual operation of the "f" stops is possible, if required. A revolving sunvisor eliminates unwanted overhead skylight, insuring accurate exposure of even brightly lit scenes.

A friction-lock orienting back permits mounting the Auto-EX in convenient position on the front of the camera. Made to a very compact design, it is smaller than a lens-plus-exposure meter. Spacing between stop positions has been made wide to insure precision setting of "f" stops. It is equipped with a filter-retaining ring permitting use of 21.5mm filters. The fast $f/1.9$ lens is prefocused for simplicity and convenience. List price is $49.95 as announced by Elgeet Optical Co., Inc., 828 Smith St., Rochester 6, N.Y.



A Professional Film Viewer for 35mm film has been announced by Camera Equipment Co., 315 West 43 St., New York 36. The viewer enables the film editor to view the film from left to right on a $6 \times 4\frac{1}{2}$ in. screen. It is portable and enclosed in a metal case. A counter and/or sound reader can easily be attached. The viewer is priced at $500; the counter at $75; and the sound reader at $150. A viewer for use with 16mm film is also available.

A vidicon studio camera, a professional-type slide projector for TV stations, a 21-in. color TV monitor and a 500-w high-band VHF TV transmitter are among the developments displayed by the Radio Corp. of America at the 35th annual trade show of the National Association of Radio and Television Broadcasters (NARTB), April 7–11, Conrad Hilton Hotel, Chicago.

The slide projector features a loading

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RE-1
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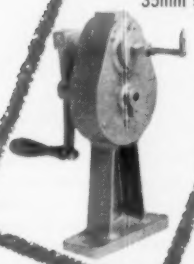

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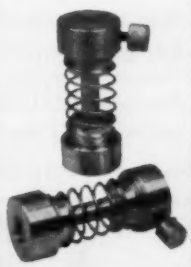

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capacity of 36 2 × 2 in. color or monochrome transparencies. Known as the TP-7A it is reported to be useful with virtually all types of TV camera systems.

The new monochrome TV studio camera (TK-15) is engineered with a vidicon-pickup tube and advanced electronic circuitry for economy in broadcast operations. The 21-in. color monitor for presentation of color pictures from live and film cameras is scheduled to be available this year. It features feedback stabilization throughout, kinescope protection from loss of horizontal deflection or video overdrive, regulated voltages for stability, and underscan provisions for examination of picture corners.

Two Houston Fearless Processing Machines and a Continuous Contact Printer, provided by the American manufacturer for the Australian Broadcasting Commission, Melbourne, were used in making motion pictures of the 1956 Olympic Games. Photographic production of 96 motion-picture cameramen covering events totaled more than three-quarters of a million feet of processed film in 15 days. The film was sent from Melbourne to Herschell's Film Laboratories in nearby Joliment by motorcycle, the film arriving hourly from 6 P.M. to 3 A.M. A staff of 30 experts completed processing, duplicating and editing of the daily output by 7 A.M. the same day. A Houston Fearless Continuous Contact Printer provided for a heavy demand of 16mm copies of film. The two Processors nightly processed up to 5,000 ft of film an hour, it was reported.

Fifteen-watt amplifiers, for use in large auditoriums, provide a 50% increase in power and distortion-free sound at high levels in the new Bell & Howell's Filmosound 16mm magnetic-recording projector. The added reserve amplification, not needed in normal operation, is provided to compensate for variations in film prints and assure full sound volume in low-voltage areas.

Soundtrack can be recorded on film, and both magnetic and optical (conventional) sound and silent films can be projected. There are separate tone controls for independent adjustment of treble and bass frequencies. Dual recording-level lamps (instead of a single lamp) indicate specifically when the recording level is correct. A transistor eliminates vibration noise during magnetic playback, and switch clicks during recording are minimized by the circuit design. A monitor input jack for use with the Bell & Howell monitor mixer or monitoring headset is located on the rear amplifier panel.

With the new Filmosound, a magnetic soundtrack can be recorded on any 16mm film — sound or silent, single- or double-perforated. When the film already has an optical soundtrack, Bell & Howell can add a magnetic half-track which permits the use of both magnetic and optical sound.

A built-in interlock automatically prevents accidental erasure of magnetic recording on film. Available as an accessory are a record-erase lock and key to prevent unauthorized recording or erasure.

Two versions of the projector are available. The 302E in a single case, with built-in 8-in. speaker, retails at $734. The 302D is available with a 12-in. auxiliary speaker at $814, or with a 12-in. 25-w power speaker at $884. Both 12-in. speakers are housed in matching cases.

A bulletin issued by the Vicra-Lite Screen Division of L. E. Carpenter & Co., Empire State Bldg., New York 1, describes a lenticular screen designed to provide good viewing for all seats. Originally developed for CinemaScope, the screen is adaptable to small theaters and to various projection angles. The bulletin is available upon request from the company.

The C-I Theatron, an all-electronic control system for stage, nightclub and TV studio lighting, has been announced by Century Lighting, Inc., 521 West 43 St. A compact 2-scene preset console provides for proportional dimming and proportional cross fading. All of the 30 dimmers may be of 2000-w capacity or 22 may be of 1000-w and 8 of 4000-w capacities. The system is recommended for high school, university and community theater use or for small TV studios. Recommendations for layouts are available upon request.

The Fedi XII T Projector has been announced by Ing. Angiolo Fedi, 6 Via S. Gregorio, Milano, Italy. The new projector is an adaptation of the firm's Fedi XII S (p. 530 of the Sept. 1956 *Journal*) with such additional features as a self-contained cool-

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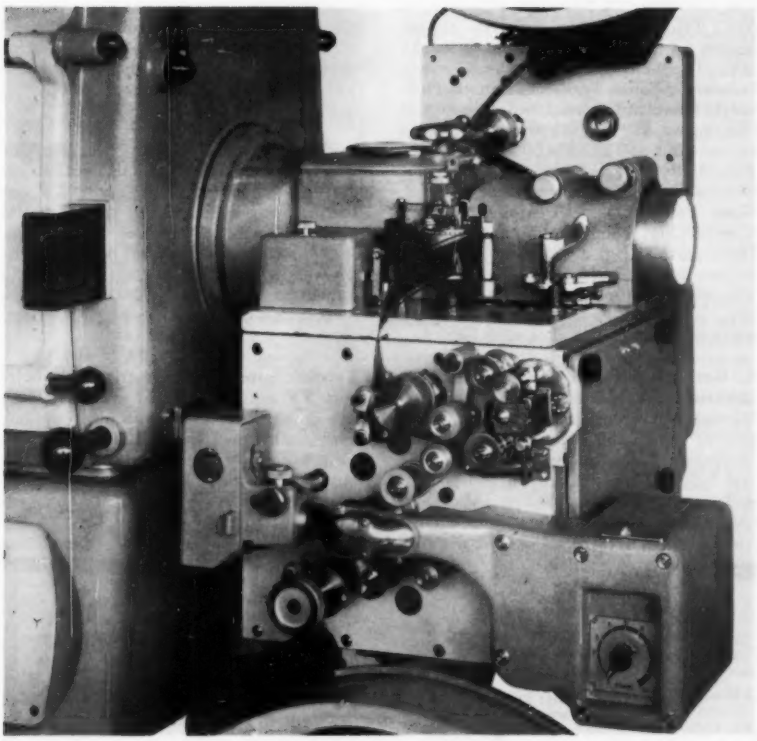
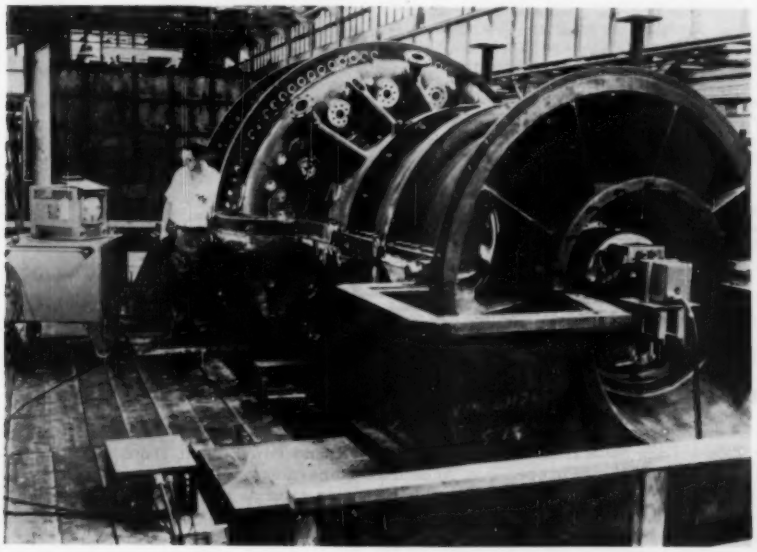


ing system, turret lens holder and fully adjustable aperture plate. The camera-type turret provides for simultaneous and continuous projection of three different focal-length lenses for standard, wide-screen or VistaVision and CinemaScope ratios. A heat-absorbing shutter forms an essential part of the cooling device. A set of glass filters absorbs heat while permitting the light rays to pass through unchanged. Application of the heat-absorbing crystals is reported to have lowered the temperature of the center of the aperture plate from 515 C to 265 C.

Aligning turbine shells is a new closed-circuit TV camera use developed by the General Electric Co. Technical Products Dept., Syracuse, N.Y. Known as the Intratel, it is used in positioning 4- to 5-ton gas turbine sections, which previously were aligned by stretching a taut wire through the turbine and estimating when the shells were in position. The present method is to line up the turbine shells, then the camera is bolted, leveled and centered on the first or master shell. When another shell is to be attached, a target is centered in the new shell and the camera lens focused to the known distance to the target. By watching the monitor located about 15 ft from the camera, the engineer can accurately align the new shell and adjust the connecting bolts accordingly.



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The use of closed-circuit television in traffic control has been proposed by an official of the General Electric Co. Technical Products Dept., Syracuse, N.Y. Under the proposed plan, closed-circuit TV cameras would be strategically located along busy cross-city intersections or other important traffic arteries. Each camera would be focused on a system of mirrors at the intersection. The mirrors, in turn, would afford a view of traffic flow from all four directions of the intersection. By a system of measured stadia or graduated marks on each mirror, the distance of the traffic from the mirror would be calculated.

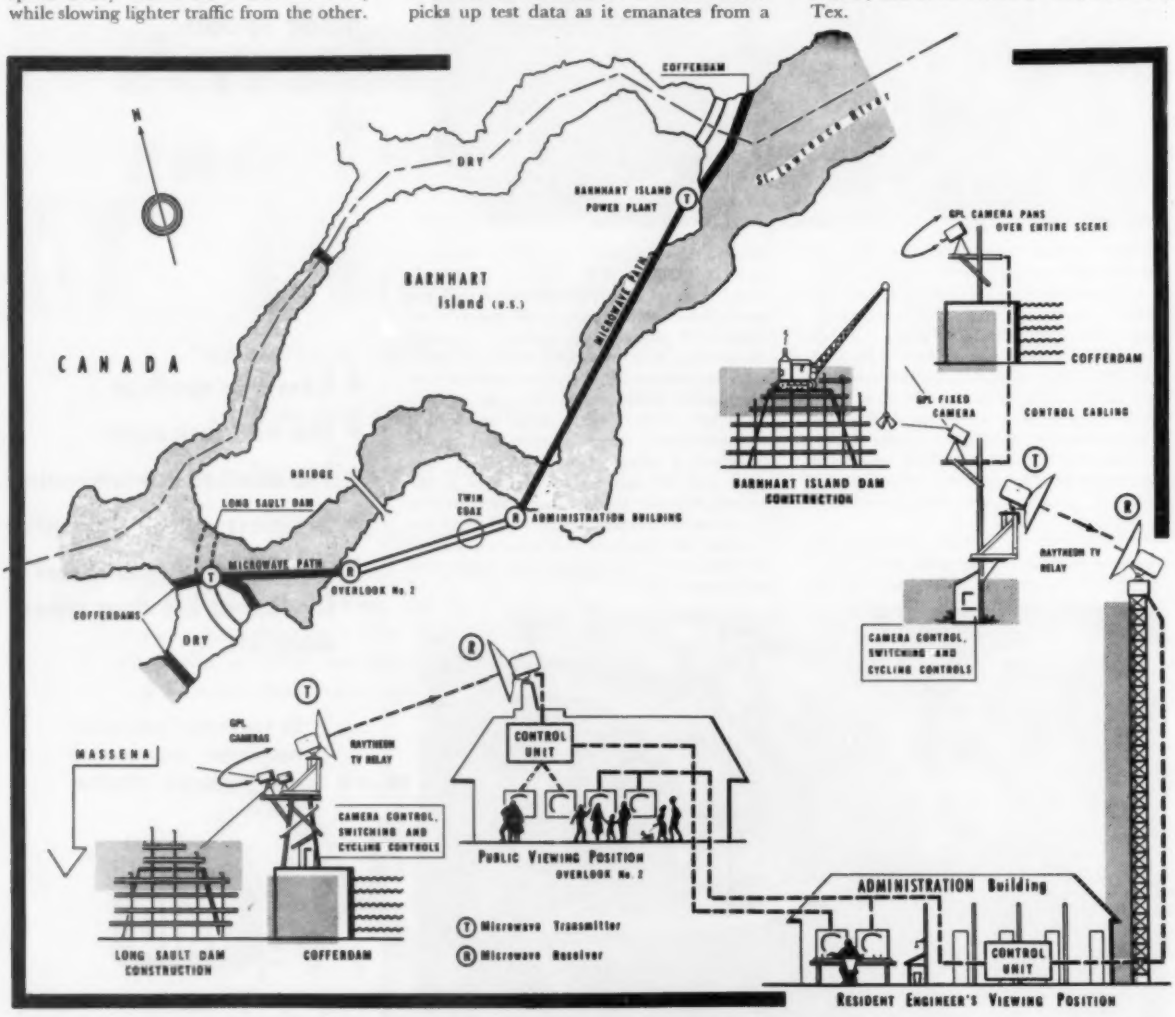
A traffic coordinator, seated in front of a bank of television monitors, or receivers, at a central traffic bureau, could thus view traffic conditions at any number of intersections. The closed-circuit TV system, combined with radio controls, would give the traffic coordinator pushbutton control over the timing of the red and green lights at each intersection. In this way, he could speed heavy traffic from one direction, while slowing lighter traffic from the other.

The East-West TV Network, 2924 Auburn Ave., Toledo 6, Ohio, offers two closed-circuit package deals reaching 9 or 11 cities. The 9-city package reaches Chicago, Columbus, South Bend, Cincinnati, Pittsburgh, Cleveland, Detroit, Indianapolis and Huntington, W. Va., at a price of $9,746.39 for one hour and $12,954.00 for two hours. The 11-city package reaches Minneapolis, Omaha, Wichita, Mason City, Quincy, Sioux Falls, S.D., Des Moines, Peoria, Kansas City, Mo., Madison, Wis., and Davenport, Ia., at a price of $11,965.00 for one hour and $16,427.00 for two hours. The origination may be from any included city, and union operation and network supervision are provided at each location.

A General Electric closed-circuit TV camera about twice the size of a cigar-box is being used by engineers at the company's aircraft jet-engine development center, Cincinnati, Ohio, to reduce testing time and help relieve the critical shortage of skilled technical assistants. The TV camera picks up test data as it emanates from a computer and is registered on a pen recorder. The data is then transmitted to the test site some 200 ft distant where it is interpreted by a test engineer and checked with operations of hydraulic controls.

A nation-wide training program for technicians specializing in the installation and maintenance of closed-circuit TV systems is being conducted by the Technical Products Dept. of General Electric Co. A G-E official has estimated present industry-wide sales of closed-circuit TV at $6 million annually and the same official predicts sales of $75 million within 10 years.

To distribute RCA industrial closed-circuit TV equipment and systems, RCA has announced the appointment of four additional firms: Eastern Theatre Supply Co., Buffalo, N.Y.; Ernie Forbes Theatre Supply, Detroit; Lake Service Corp., Boston, and J. A. Walsh & Co., Houston, Tex.



Closed-circuit television is being used to supervise the building of dams by the Power Authority of the State of New York as part of the St. Lawrence Seaway development. At both the 2350-ft Long Sault Dam and 3230-ft Barnhart Island Power Plant Dam, two cameras, products of General Precision Laboratory, Inc., Pleasantville, N.Y., are in operation. At each dam, one camera is stationary and looks across the entire site; the other, equipped with a telephoto lens, scans a 120° arc. The fixed and moving cameras are automatically switched. Television signals are transmitted by Raytheon Mfg. Co. microwave relays to the resident engineer's office where a few minutes observation of the TV monitors is equal to several hours travel to the work sites.

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Apprentice Film Editor. Seeks summer position. Currently cinema student at CCNY; previously at UCLA with top grades. Meyer Odze, 1669 Macombs Rd., Bronx 53, N.Y.

Laboratory Engineer. Over 10 years in design, procurement and co-ordination of plant, printing, developing and auxiliary equipment. Esp. interested in film sequence-of-operation planning or similar industrial engineering function in sympathy with MIT degree and experience. Position might be with a lab, producer, ad agency, or TV facility. Fred Bray, 40 Ryerson Place, Closter, N.J. Closter 5-1766J.

Asst. Film Editor. Seeks position in N.Y. area: Will graduate from CCNY in June, completing courses of Inst. of Film Techniques. Currently working 20 hr a week on a major Institute project. Experienced with all cutting room apparatus. Chairman of CCNY Chapter, SMPTE. Morton Schwartz, 1997 Huges Ave., Bronx 57, N.Y.

Cinematographer—Art Director. Graduate university-level motion-picture photography and art-directing courses, Academy of Arts, Holland, 1945–50. Over 3 yr experience in planning and production of TV film presentations and film commercials, incl. writing, direction and coordination. Presently employed as assistant film director and set designer. Speaks French, German, Dutch and English. Desires contact with organization active in film production. Excellent references in U.S., Canada and Europe. Resume on request. G. Van Duyn, Wingham, Ont., Canada.

Motion Picture and Television Production December graduate of Television Workshop; thorough knowledge of film and television techniques, including film transmission equipment, kinescope recording, optics, film markets, library methods. Specialty film genealogy, set lighting and decorating, and electrical effects. Currently secretary of the Society of Cinema Collectors and Historians. Age 33, married. Résumé on request. Larry Morales, 37-16 55th St., Woodside, N. Y.

Cameraman. College graduate with B.S. in cinema seeks position as cameraman or assistant cameraman with active motion-picture production group. Presently working with small industrial film outfit as assistant cameraman, film editor and sound recordist. Age 25, married, one child. Resume on request. Write: J. B. E., 139 Constant Ave., Staten Island 14, N. Y.

Positions Available

SMPTE Staff Engineer. Applications invited for position at SMPTE headquarters. Duties involve servicing SMPTE engineering committees and organizing and reporting committee activities at Society Conventions, liaison work for the Society in the establishment of national and international motion-picture standards, and handling engineering inquiries addressed to the Society. The Staff Engineer will also have responsibility for maintaining the technical standards of the Society's test film program and for initiating and supervising the manufacture of new films. Submit full résumé to Executive Secretary, SMPTE, Room 1004, 55 West 42 St., New York 36.

Service Engineer, with good mechanical ability and experience in field of motion-picture lab equipment, automatic printers and developing machines. Write: E.M.B.Y., Apt. 1908, 253 West 72 St., New York, N.Y.

Aerial Photographic Technician sought to take motion pictures and still photographs of equipment under aerial tests. Must be experienced in installation and alignment of aerial cameras, familiar with wiring and control circuits, and be able to operate and trouble shoot aerial camera wiring. Capable of performing laboratory work to produce photographs and records obtained from motion-picture and still cameras and photorecorders, and of supervising all aerial photographic activities. Relocation expenses paid; excellent salaries and working conditions; advancement by merit; company-paid benefits. Write qualifications and experience to: Mr. A. J. Page, Department 334, Personnel Administration, IBM Corporation, Airborne Computer Laboratories, Owego, N.Y.

Representative calling on manufacturers and users of photographic, optical and electronic instrumentation. To represent and solicit new business for photographic engineering firm. Should have contacts among aircraft companies, government agencies and manufacturers and users of light and allied equipment for commercial, industrial or military applications. Inquiries are invited in strict confidence. Foto Engineering Co., 495 Hempstead Turnpike, West Hempstead, L. I., N. Y.

Sales Engineer for sound-on-film 16mm cameras. Start $6,600/yr with opportunity for advancement with established company; this is our 26th year in business, see our ads in your SMPTE Journals. To work in Hollywood office with Sales Manager, handle customers and answer mail, covering sales and service of Auricon 16mm sound-on-film optical and magnetic recording cameras. Technical knowledge of, or experience as 16mm producer, professional cameraman, soundman, or both, is necessary. Also ability to write good technical letters. Send résumé, with references, to: Walter Bach, Berndt-Bach, Inc., 6900 Romaine St., Hollywood 38.

Engineering Director. Top-level engineer required for long-established motion-picture equipment manufacturing concern. Must have long experience with automatic printers, additive and subtractive, and with developing machines; able to discuss equipment problems with customers and explain and demonstrate the company's equipment. Send résumé, with references, to: E.M.B.Y., Apt. 1908, 253 West 72 St., New York, N.Y.

Motion Picture Equipment Sales Representative. Familiar with professional production equipment. Write fully or call Mr. Florman, Florman & Babb, Inc., 68 West 45th St., New York 36. MU 2-2928.

Motion Picture Equipment Maintenance Men. Expert on Mitchells, Bell & Howells, Auricons, Cine Specials, Moviolas, amplifiers, etc. Write fully or call Mr. Florman, Florman & Babb, Inc., 68 West 45th St., New York 36. MU 2-2928.

TV Lighting Sales Engineer. Servicing major networks, smaller studios and distributors. Salary commensurate with experience. Century Lighting, Inc., 521 West 43 St., New York. N. Sonnenfeld.

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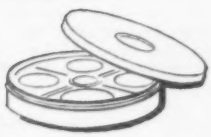

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Meeting Calendar

National Academy of Sciences, Apr. 22–24, Washington, D. C.
Symposium on the Role of Solid State Phenomena in Electric Circuits, Polytechnic Institute of Brooklyn, Apr. 23–25, Engineering Societies Building, New York.
Armour Research Foundation, National Industrial Research Conference, Apr. 24, 25, Conrad Hilton Hotel, Chicago.
American Physical Society, Apr. 25–27, Washington, D. C.
Institute of Radio Engineers, Annual Spring TV Conference, Apr. 26, 27, Engineering Society Bldg., Cincinnati, Ohio.
81st Semiannual Convention of the SMPTE, including Equipment Exhibit, Apr. 29–May 3, Shoreham Hotel, Washington, D. C.
Electronic Components Symposium, May 1–3, Morrison Hotel, Chicago
Armed Forces Communications and Electronics Association, May 20–22, Sheraton-Park Hotel, Washington, D. C.
American Society of Mechanical Engineers, Design Engineering Conference, May 20–23, Coliseum, New York.
Radio Parts and Electronics Equipment Shows, May 20–23, Conrad Hilton Hotel, Chicago.
American Institute of Chemists, May 22–24, Sheraton-Mayflower Hotel, Akron, Ohio.
Acoustical Society of America, May 23–25, New York.
American Rocket Society, Semiannual Meeting, June 9–13, Hotel St. Francis, San Francisco.
American Society for Testing Materials, June 16–21, Chalfonte-Haddon Hall, Atlantic City, N. J.
Professional Group on Electronics, I. R. E., National Convention on Military Electronics, June 17–19, Sheraton-Park Hotel, Washington, D. C.
American Institute of Electrical Engineers, Summer General Meeting, June 24–28, Montreal, Que.
British I. R. E., June 27–July 1, Cambridge University, England.
International Symposium on Physical Problems of Color Television, sponsored by International Union of Pure and Applied Physics, French Physical Society, French Society of Radioelectricians, French Society of Vacuum Engineers, July 2–6, National Conservatory of Arts and Crafts, Paris.
Western Electronic Show and Convention, Aug. 20–23, Cow Palace, San Francisco.
Biological Photographic Association, Aug. 27–30, Kahler Hotel, Rochester, Minn.
82nd Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 4–9, Philadelphia-Sheraton, Philadelphia.
National Electronics Conference, Oct. 7–9, Hotel Sherman, Chicago.
American Standards Association, Eighth National Conference on Standards, Nov. 13–15, San Francisco.
83rd Semiannual Convention of the SMPTE, including Equipment Exhibit, April 21–26, 1958, Ambassador Hotel, Los Angeles.
84th Semiannual Convention of the SMPTE, Oct. 20–24, 1958, Sheraton-Cadillac, Detroit.
American Standards Association, Ninth National Conference on Standards, Nov. 18–20, 1958, Hotel Roosevelt, New York.
85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4–8, 1959, Fontainebleau, Miami Beach.
86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 6–10, 1959, Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections Subsections and Chapters, and of the Committee Chairmen and Members will be found in Part II of this issue.

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